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MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

THE UNITED KINGDOM.

Figures and Descriptions

ILLUSTRATIVE OF

BRITISH ORGANIC REMAINS.

DECADE X.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE:
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1861.

3052.

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BRITISH FOSSILS.

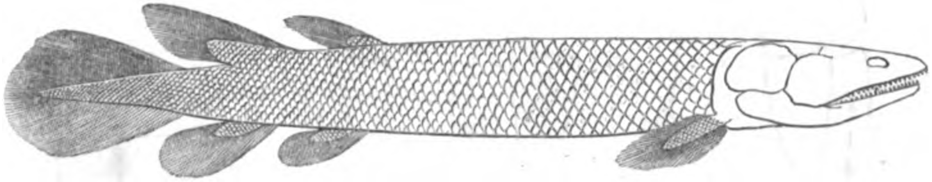
DECADE THE TENTH.

PRELIMINARY ESSAY upon the SYSTEMATIC ARRANGEMENT of the FISHES of the DEVONIAN EPOCH, by THOS. H. HUXLEY, F.R.S., Professor of Natural History, Government School of Mines.

THE endeavour to determine the systematic position of *Glyptolæmus*, a genus of Devonian fishes, first described and figured in Dr. Anderson's interesting work upon "Dura Den,"* and more fully discussed and illustrated in the course of the present Decade, has gradually led me to reconsider the whole question of the classification of the fishes of this epoch and, eventually, to arrive at results which seem to necessitate an important modification of the received arrangement of the great order of Ganoidei.

I propose, in the course of the pages of this preliminary essay, to take the reader through the various steps of the argument which terminates in this conclusion; and, commencing with a brief enumeration of the most important characters of *Glyptolæmus*, I shall proceed to the discussion of the peculiarities of other genera, more or less nearly allied to it, with the view of demonstrating, finally, that *Glyptolæmus* is a tolerably typical member of a large and well defined family of Ganoids, which abounded in the Devonian epoch, but whose members have been less and less numerous in more modern formations, until, at present, its sole representative is the African *Polypterus*.

FIG. 1.



Restoration of *Glyptolæmus*.

Glyptolæmus Kinnairdi (fig. 1, and Plates I. and II.), the only known species of its genus, is a fish with an elongated body, a depressed head, and a conically tapering caudal extremity. The orbits are situated forwards, while the gape extends far back. The frontal bones (fig. 2) are distinct from one another and from the parietals, which last are not shorter than the frontals, and, though in contact throughout the whole length of their inner margins, are perfectly distinct from one another. Three bones, or scales (for they seem to partake as much of the nature of the latter as of the former), a median and two lateral, roof in the occipital region. The middle of the jugular region, or that comprised between the two rami of the mandible upon the under surface of the cranium, is occupied by two large, triangular, squamiform, bones—the *principal jugular plates* (j^1); while the interval left between them and the mandibular rami, on each side, is taken up by a series of smaller, quadrate plates, which increase in size from before backwards—the *lateral jugular plates* (j^2). There is no rhomboidal *median jugular plate* interposed between the anterior part of the inner edges of the principal jugular plates. The teeth are of two kinds; smaller, set in a close series along the edges of the jaws; and larger, placed at intervals along the palate, and perhaps along the inner side of the mandible. The larger teeth have grooved bases, and appear to be composed of dendrodentine.[*]

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* Dura Den; a Monograph of the Yellow Sandstone, and its remarkable Fossil Remains. 1859.

FIG. 2.

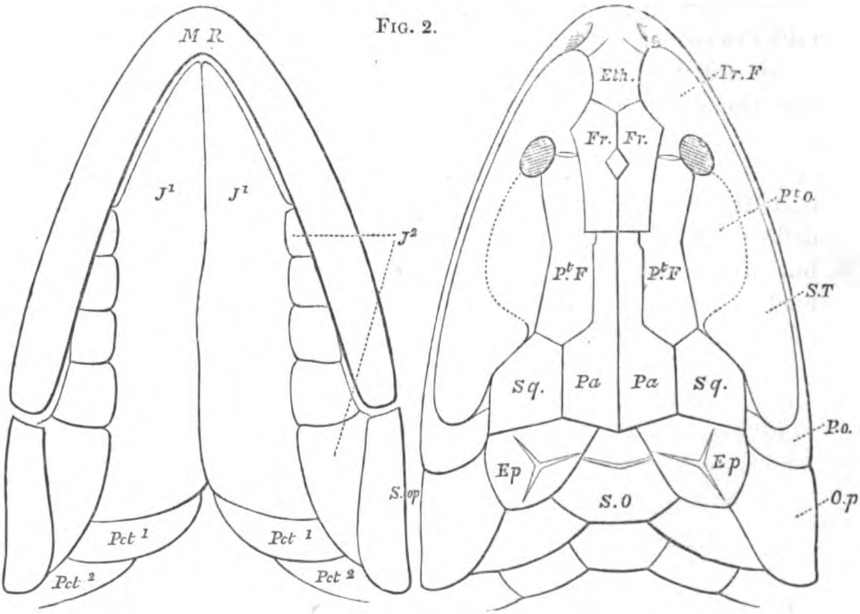

Diagram of the Head of *Glyptolæmus*.—For an explanation of the letters, see p. 40.

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[*] Prof. Pander applies the term "Dendrodonts" to those fishes the pulp cavities of whose teeth appear branched, in consequence of the folding of their walls; and such folded dentine may be conveniently termed "dendrodentine."

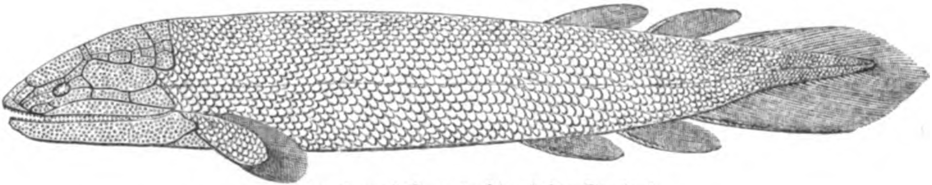
The pectoral arch is covered by two triangular, sculptured, osseous plates (Pct^1, Pct^2), which meet in the middle line below and are superficial to the so-called coracoids. The paired, or pectoral and ventral, fins are lobate; that is, the fin has a central axis, or stem, covered with scales. There are two dorsal fins, placed in the posterior half of the body. The ventral fins are situated under the first dorsal, and are succeeded by a single anal. The caudal fin, whose contour is rhomboidal, is divided into two equal lobes by the prolonged conical termination of the body; in other words, the fish is diphycercal, or truly homocercal.*

Every ichthyologist will admit the singularity of this combination of characters, but a careful analysis of the structural peculiarities presented by other fossil fishes of the same age, will show, that, so far from isolating *Glyptolæmus*, they closely unite it with several other genera.

That genus which appears to me to approach it most closely is the *Gyroptychius* of M'Coy, whose structure has received admirable elucidation from Professor Pander in his beautiful monograph "Ueber die Saurodipterinen, Dendrodonten, Glyptolepiden und Cheirolepiden des Devonischen Systems" (1860), to which I may refer those who desire to obtain a more particular acquaintance with the details of its organization.

Here I must content myself with reproducing in a reduced woodcut (fig. 3) Professor Pander's restoration of the fish, which may be compared with the restored woodcut of *Glyptolæmus* (fig. 1), and with the Plates, and with stating that the head, the body, and the fins of *Gyroptychius* might be described in the terms which have just been applied to *Glyptolæmus*. Pander, however, makes no

FIG. 3.



Restoration of *Gyroptychius* (after Pander).

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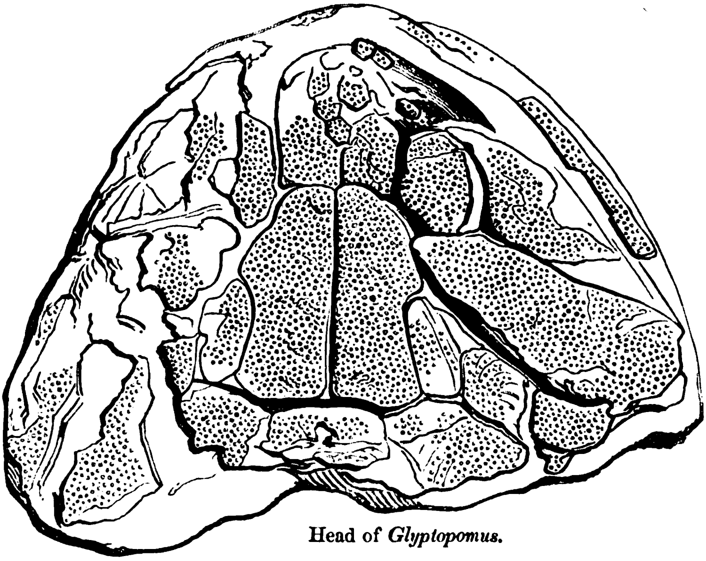
* I have endeavoured to show elsewhere (Quarterly Journal of Microscopical Science, Oct. 1858) that the so-called "homocercal" *Teleostei* of the present epoch are in reality excessively heterocercal; but the word "homocercal" is now so generally understood to signify a tail like that of most existing *Teleostei*, that I prefer to employ Prof. M'Coy's term "diphycercal" for truly homocercal tails. See, on this point, Kölliker, "Ueber das Ende der Wirbelsäule der Ganoiden, 1860," and Van Beneden, "Sur le Développement de la Queue des Poissons Plagiostomes," Bull. de l'Acad. Royale Belgique, 1861.

mention of lateral jugular plates; the scales, which are as often oval as rhomboidal, are sculptured in a very different manner from those of *Glyptolæmus*, and, according to Pander, the anterior edges of the median fins are provided with fulcra.

Glyptopomus (Agassiz) is another genus whose close alliance with *Glyptolæmus* is evidenced by the structure of its skull, of which there is a fine specimen in the British Museum. It is very depressed and has two distinct frontal bones, separated anteriorly by a small rhomboidal plate; there are two long and distinct parietals, and three bones, one median and two lateral, behind these, covering the occiput. The orbits are situated far forward, the gape is greatly elongated, there are two principal jugular plates, and the pectoral arch is as in *Glyptolæmus*. A fine specimen in the Museum of Practical Geology shows that some of the teeth, at any rate, were of large size, and longitudinally grooved at their bases.

FIG. 4.



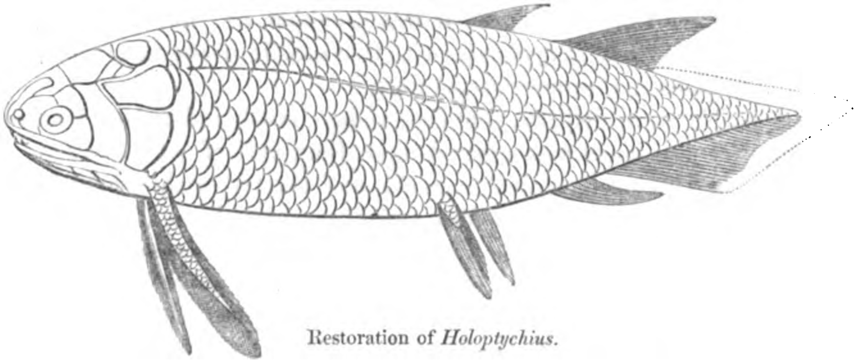
Head of *Glyptopomus*.

Only three specimens of *Glyptopomus* are at present known, and no one of these exhibits either the paired or the median fins; but the close correspondence of the cranial structure of this genus with that exhibited by *Glyptolæmus*, leaves no doubt on my mind that, when discovered, the fins will be found to be similar, in all essential respects, to those of the latter genus (*see* note, p. 46). The sharply rhomboidal scales are thicker in proportion than those of any other Devonian fish, and are pitted upon their surfaces like the scutes of the Crocodilia.

As has been seen, the angles of the scales of *Gyroptychius* are apt to become rounded off, so as to present a transition from the rhomboid to the cycloid contour, and, hence, it is less surprising than it seems at first sight, to find fishes with eminently cycloid scales, so similar, in all the essential features of their organization, to *Glyptolæmus*, *Gyroptychius*, and *Glyptopomus*, as imperatively to demand a place near them in any natural arrangement.

Holoptychius (Agassiz), for example, has a depressed head (though deeper than that of *Glyptolæmus*), and a conically tapering caudal extremity; the orbits are situated far forwards and the gape extends far back. The frontal bones are distinct from one another, and from the parietals, which last are large and co-adapted, though quite distinct; the occiput is covered in by three bones, a median and two lateral; there are two principal and a number of lateral jugular plates, and there is no rhomboidal median jugular plate interposed between the principal jugulars. Some of the teeth are larger than the others, and longitudinally striated at their bases. The paired fins are very acutely lobate, and there are two dorsal fins placed in the posterior half of the body. The ventral fins are situated under the first dorsal, and are succeeded by a single anal.

FIG. 5.



Restoration of *Holoptychius*.

Thus far, the reader who compares this description with that of *Glyptolæmus* already given, will find the two essentially identical. But the tail of *Holoptychius* differs from that of *Glyptolæmus*, in that it is little more than semi-rhomboidal, the upper moiety being far less developed than the lower,* and the scales are, in form and sculpture, widely different from those of the latter genus.

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* In my restoration of *Holoptychius* (Dr. Anderson's "Dura Den," p. 69) I have represented the fish with a diphycercal tail; but I am now prepared to admit that the evidence on which I rested this conclusion was not trustworthy, and that Sir Philip Egerton's view of the case is in all probability correct. However, I must say, that I have never yet seen a *Holoptychius* with its caudal extremity in a perfectly satisfactory state of preservation.

That *Platygnathus* (Agassiz), if we restrict the name to the fish whose caudal extremity is figured by Agassiz ("Vieux Grès Rouge," Tab. 25), is very closely allied to *Holoptychius* cannot be doubted; indeed, the only serious question regarding it, in the absence of further materials for its reconstruction, seems to be, whether it should really form a separate genus; so that I may pass on to another generic type, *Glyptolepis* (Agassiz).

This genus is briefly mentioned in the "Recherches sur les Poissons Fossiles," ii. p. 179, but Agassiz first described and figured species of it in the "Monographie des Poissons du Vieux Grès Rouge," p. 62, where *Glyptolepis* heads the family of the "Célacanthes," and is said to comprise fishes of moderate size, with pyriform bodies, and with heads which are small, short, flattened, and have an almost semicircular contour. The rami of the mandible are stated to be beset throughout their length with a single series of small, equal, conical teeth, which seem to approach those of *Dendrodus* and *Holoptychius* in structure, and to have a dendritic pulp cavity surrounded by folded dentinal walls. *Glyptolepis microlepidotus*, however, is said (p. 65) to possess large teeth alternating with small ones in the lower jaw. The upper jaw projected beyond the lower a little, and had similar teeth. The throat was provided, as "in all ancient " Cœlacanths and in *Polypterus*, with two mobile triangular plates, " which replace the branchiostegal rays."

The scales were delicate, rounded, and so much imbricated that the anterior one sometimes covered more than half of its successor. Their upper faces were entirely smooth, and covered with a delicate layer of enamel, which, apart from some concentric lines of growth, exhibited no ornamentation. Their inferior faces were also smooth, and formed by a very delicate layer of bone. The mass of the scale was formed by an osseous and spongy substance, adorned with fine rays, which radiated from the centre of the scale. These rays were intersected by concentric and circular lines, so that a scale, whose smooth layer is worn away, presents a number of small elongated cells, disposed in circular series, almost like the seats of an amphitheatre.

In the "Additions et Corrections," (l. c., p. 140), Agassiz adds a description of the scales of *Glyptolepis elegans*, which supplies an important correction to that just given. Referring to Tab. 21 a, he says, "The figure 2 a represents a scale of its natural size, and " fig. 2 the same magnified. *The folds of the surface which con-* " *stitute the ornaments of the visible portion of the scale* are more

" distant than in the foregoing species." Thus it is admitted that *Glyptolepis* has not smooth, but sculptured scales, as, indeed, the name of the genus implies.

Agassiz enumerates a caudal, two dorsal, and two anal fins, but states that the existence of pectorals is doubtful, and that, in any case, they must have been small and inconsiderable. The ventral fins, on the other hand, are said to possess a singular structure, " which is also to be found in *Megalichthys*." A series of plates extends as a pointed band along the belly, and, becoming free at its posterior extremity, carries numerous rays on both sides, and thus forms a ventral fin, which, from the manner in which its rays are disposed, is very like an eel's tail. (Tab. 21, fig. 2.) I have examined the specimen here referred to, which forms a part of Sir Philip Egerton's collection, and, with Professor Pander, I feel satisfied that the fin in question is the very long, acutely lobate, pectoral, bent back in such a manner, that the proximal half of its posterior edge is covered by the lower margin of the abdomen of the fish.

Professor Agassiz goes on to say that the two dorsals are opposed to the two anals, and are situated so far back that the caudal directly follows them. They are so close together that the last ray of the first touches the first ray of the second. The second dorsal and anal are higher than the first, and the caudal is large, heterocercal, and triangular, appearing to be almost vertically truncated; its superior division bears numerous little fulcra.

Hugh Miller (" Old Red Sandstone," 1841,) made some important improvements upon Agassiz' description and definition of *Glyptolepis* He pointed out with great justice (and figured a specimen demonstrating the fact), that there is only one anal, the second, or posterior of Agassiz, the ventrals having been mistaken for an anterior anal, and he describes and gives a sketch of the sculptured outer surface of the scales.

Professor Pander, in the Monograph already cited, has carried the work of rectification still further, though even he ventures upon no restoration of *Glyptolepis*, seeming to be unacquainted with the figure of the body of the fish, from a specimen more complete than any of those of Agassiz, or of his own, given by Hugh Miller.

In addition to what was already known, he states that the principal jugular plates are separated, anteriorly, by a small rhomboidal one, and he makes the observation that " these plates, which among " living fishes occur double only in *Polypterus*, and are among fossils " known only in *Osteolepis*, *Diplopterus*, *Megalichthys*, and *Gyroptychius*, lead to the supposition that the composition of the cranial " and facial bones will differ in no important respect from what is "found in them;" and this supposition is, he states, confirmed by the similarity of the upper and lower jaws and teeth. Behind the jugular plates, and applied to their hinder edges, Professor Pander finds two others, which meet in the middle line, and resemble those which lie upon the under surface of the pectoral arch in *Polypterus*.

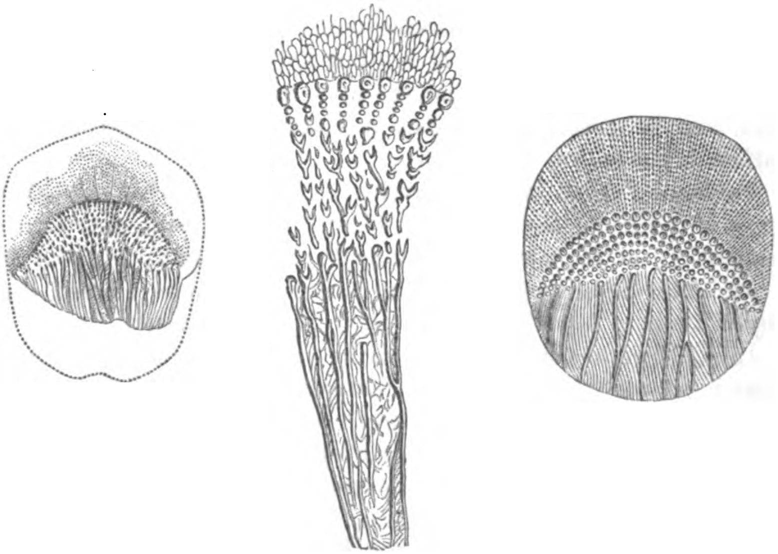
The scales are, in general, rounded, sometimes circular, sometimes oval, sometimes more or less quadrate, by reason of the less rounding off of their angles. They overlap in different degrees, and their external sculpture is different in different parts of the body, whence arises such an amount of unlikeness, that different species might readily be founded on scales from different regions.

The sculptured surface presents two divisions, one, more anterior, exhibits small tubercles with projecting points, which are convex posteriorly, concave anteriorly, and are disposed in regular series converging towards a central point, which, however, they do not reach.

The posterior segment is covered with wavy longitudinal costæ, which gradually diminish in thickness from the anterior towards the posterior edge.

Professor Pander gives a figure of this peculiar sculpture, a woodcut copy of which I subjoin, and side by side with it a careful drawing of the sculpture of the scale of a *Glyptolepis* from Wick, in an even better state of preservation.

FIG. 6:—The two left hand figures represent the scale from Wick of the natural size and its sculpture magnified; the right hand figure is copied from Pander's Monograph.

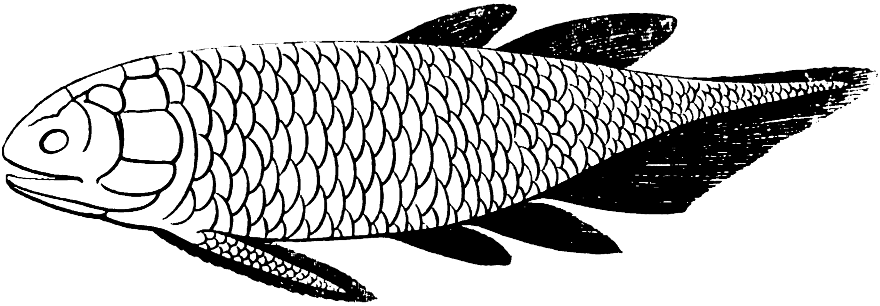


There can be no doubt that the scales of *Glyptolepis* possess the ornamentation here represented. Not only does Professor Pander positively state that the scale figured by him was worked out from a Lethen Bar nodule, and formed part of the unquestionable *Glyptolepis* represented in his Plate 7, fig. 4; but the specimen of *Glyptolepis leptopterus* represented by Agassiz in the "Vieux Grès Rouge," Tab. 21, fig. 2, and now in Sir Philip Egerton's collection, has obviously sculptured scales and cranial bones. And I find that by scraping away the inner layers of the scales of undoubted examples of this genus, in the Museum of Practical Geology and in that of the Royal College of Surgeons, the points and ridges of the sculpture remaining imbedded in the rock are easily displayed. The clear recognition of the fact that this elegant structure really characterizes *Glyptolepis* is of great importance, for, in the first place, it enables one to discriminate between *Holoptychius* (whose scales have no semilunar area of backwardly directed points) and *Glyptolepis*, and, in the second place, it places beyond a doubt the justice of Professor Pander's conclusion that the scale figured by Miller in the "Footprints," as appertaining to *Asterolepis*, really belongs to *Glyptolepis*.

Pander states that the rays of the median fins are supported upon long interspinous bones, and that the paired fins are very much approximated; the very long pectorals extending far beyond the bases of the ventrals, which are very broad and strong.

Specimens which I have examined show, that the parietal bones of *Glyptolepis* are large, and, like the frontals, distinct from one another; in their form and relative proportions, these bones very much resemble those of *Holoptychius*. There are three bones in the superior occipital region, one median and two lateral. A triangular, single or divided, squamosal fits in between the parietal, the external of the three superior occipital bones, and some indistinctly defined supratemporal and postorbital plates; again, as in *Holo-*

FIG. 7.



Restoration of *Glyptolepis*.

ptychius. In the opercular apparatus, the operculum and sub-operculum are large, subquadrate, and nearly equal in size. There are large dendrodont teeth (very well shown in a large specimen in Sir P. Egerton's collection) upon the inner side of the mandible. The principal jugular plates are large, but no specimen I have seen gives clear evidence of others. There is a well marked lateral line.

Apart from what has been done by Agassiz, Miller, and Pander, I think I can venture to assert from my own investigations that the woodcut fig. 7 gives an essentially faithful restoration of *Glyptolepis.** But a comparison of this figure with that of *Holoptychius,* given above, is sufficient to prove the close affinity of the two genera,—in fact, their family relationship.

Pausing now, to look back over the ground which has been traversed, we find that the six genera which have been discussed, viz., *Glyptolæmus, Glyptopomus, Gyroptychius, Holoptychius, Platygnathus,* and *Glyptolepis,* possess the following characters in common:—Two dorsals, acutely lobate paired fins (ventrals of *Glyptolepis ?*); principal and lateral jugular plates, and no branchiostegal rays; more or fewer large teeth with grooved bases, and consequently folded dentine; sculptured scales and cranial bones,—among which last are to be noted three occipital plates,—large, distinct, parietals, and equally distinct frontals. In short, they constitute a family of Ganoids, which I propose to call GLYPTODIPTERINI, and which may again be subdivided into two groups, or sub-families, the one, which might be called the rhombiferous Glyptodipterini, containing the genera *Glyptolæmus, Glyptopomus,* and *Gyroptychius,* with diphycercal tails, and for the most part rhomboidal scales; and the other, which might be termed the cycliferous Glyptodipterini, containing *Holoptychius, Platygnathus,* and *Glyptolepis,* with heterocercal tails and cycloid scales.

Professor Pander has endeavoured to prove that the teeth known as *Dendrodus* belong to fishes of the genus *Gyroptychius.* The evidence brought forward in support of this view, however, appears to me to be hardly sufficient to demonstrate its accuracy; though I think it extremely probable that the teeth and jaws, which have been referred to the genera *Dendrodus, Cricodus, Lamnodus, Platygnathus,* and *Rhizodus,* will turn out to belong to allies of *Gyroptychius,* or, in other words, to fishes belonging to the family of Glyptodipterini. And again I cannot adopt the family of "Dendrodonts" which Professor Pander has established for *Gyroptychius, Cricodus,* &c., partly because, as he defines it, it seems to me to separate naturally allied genera, and, still more, because the "dendrodont" character is quite as strongly marked in other fishes, *e.g.*, *Megalichthys*, which certainly do not belong to the same family as *Gyroptychius*, though undoubtedly related to it.

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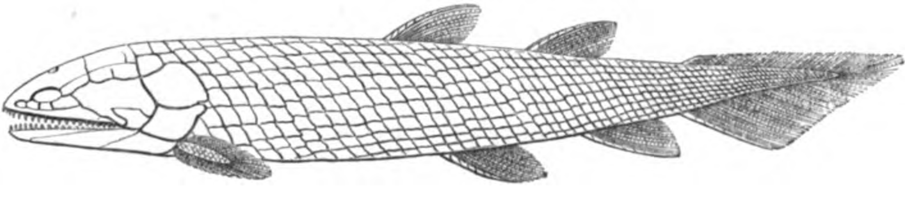
* It may be that the ventral fins are lobate, but I have seen no specimen justifying that conclusion.

The resemblances which obtain between *Gyroptychius*, on the one hand, and *Osteolepis*, *Diplopterus*, &c. on the other, have been well pointed out by Professor Pander, whose Monograph upon the Saurodipterini is not less excellent than that already cited, though it should not be forgotten that Hugh Miller long ago published an excellent restoration of *Osteolepis*.* *Diplopterus* has, in fact, the elongated form, depressed head, forward orbits, long gape, and conically tapering candal end of the body, which characterize *Glyptolæmus*. The pectoral fins are similarly, though not so acutely, lobate, and the lobate ventrals are situated far back, as in the last-named genus. The second dorsal is over the anal, and the caudal fin is rhomboidal and diphycercal.

On the other hand, *Osteolepis*, though similar to *Diplopterus* in many essential respects, has a very inæquilobed tail, much like that of *Glyptolepis*. But in *Osteolepis*, as in its most nearly allied genera, the cranial bones and the scales are quite smooth. The three occipital plates of the skull remain distinct, but the other bones of the roof of the cranium have coalesced, so as to form two bucklers, an anterior and a posterior; in which, however, the outlines of the primitive cranial bones, which have, on the whole, an arrangement similar to that which obtains in *Glyptolæmus*, are traceable. There

FIG. 8.



Restoration of *Osteolepis* (after Pander).

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* *See* "The Old Red Sandstone," Pl. iv. fig. 1, *Osteolepis major*. It appears from this figure that even the lobation of the pectoral fin had not escaped Hugh Miller, though he does not particularly refer to it in the text. Before Professor Pander's work appeared in this country, I had obtained from Caithness, by the well-directed activity of Mr. Peach, and placed in the Museum of Practical Geology, a series of specimens illustrating all the chief structural characters of *Osteolepis* as detailed above. The lobate pectorals of *Osteolepis* and *Diplopterus* are exhibited very well by specimens in the Hunterian and British Museum; the fact that "small ganoid scales are continued upon" the bases of the pectorals being noted in the description of No. 567 in the Catalogue of the former Museum.

are no lateral jugular plates, but the principal jugular plates are separated, anteriorly, by an azygos rhomboidal plate.

The family of the SAURODIPTERINI, characterized by its two dorsals; less acutely lobate paired fins; jugular plates and no branchiostegal rays; smooth scales and cranial bones (among which last are three distinct occipital plates, while the other cranial bones have more or less coalesced), is thus very distinct from, though allied to, that of the Glyptodipterini. It comprises not only the genera *Osteolepis*, *Diplopterus*, and *Triplopterus* (?), but also, as I believe, a genus which has a later range in time than these, viz., the *Megalichthys* of the Coal, although the want of acquaintance with the fins of this genus renders my conclusions as to its affinities less secure than I could wish.* Agassiz does indeed affirm that *Megalichthys* has lobate fins, in a passage cited above (p. 7); but as he merely mentions the fact incidentally, I do not like to lay too much stress upon it. Nevertheless, the skull and scales of *Megalichthys* accord so closely, both histologically and morphologically, with those of the better known Saurodipterines, that I entertain little doubt as to its real place in the latter family.

Megalichthys has two principal, many lateral, jugular plates; and a single rhomboidal, azygos plate is placed between the anterior ends of the two principal jugulars. Between the upper margins of the opercula and in the upper occipital region, lie three bony plates, whose signification Professor Agassiz considers to be "somewhat enigmatical," but which really correspond exactly with the three bones which occupy the same position in the Glyptodipterini and Saurodipterini. What Agassiz terms the frontals are certainly the long parietals, whereas those which he calls "ethmoids" are the frontals. His "moignon intermaxil- " laire" is a crescentic shield, which terminates the head anteriorly, and presents distinct indications of a division into a number of pieces; the contour of the proper premaxillary portions, separated by a median suture, which form the lower and anterior boundary of the shield, being very well defined. The other parts entering into this shield represent, I believe, the prefrontals and the ethmoid. If it were amalgamated with the frontals and these with one another, we should have an almost exact reproduction of the anterior cranial buckler of *Osteolepis*. In a well preserved specimen of the skull of *Megalichthys* before me, the orbits are small circular cavities, placed at about the junction of the anterior and middle thirds of the head. They are bounded, in front and below, by a small triangular bone (like a lachrymal) as in *Polypterus;* below, by a small part of a large suborbital bone, whose anterior margin joins the premaxilla and its inferior margin the maxilla; below and behind, by another suborbital bone, fitted in between the preceding, the maxilla, and a postorbital bone. The maxilla, large and long, is narrow anteriorly, where it abuts upon the bone termed "preoperculum" by Agassiz; like the premaxilla, its edges are beset with small teeth. Agassiz says, "Le coté antérieur du mufle est " élégamment échancrè au milieu et renflè en un bec, tres obtus, " qui porte dans notre exemplaire une grosse dent canine;" and on making a transverse section of a *Megalichthys* snout I found a median, stout, backwardly projecting ridge of bone, containing two large alveoli, one on each side of the middle line. The one of these alveoli exhibits the section of the base of a large tooth with greatly folded dentine.

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* Sir Philip Egerton long since arrived at and published this conclusion in his arrangement of the Fossil Fishes in Morris's Catalogue. More recently Prof. Pander expresses the same conviction in the following terms: "Sehr gerne möchten wir aber ein " anderes Genus noch zu den Saurodipteridæ bringen, das durch den Bau seiner Kopf- " knochen; durch die Gestalt seiner Schuppen, seiner Zähne und hauptsächlich durch die " mikrospische Structur seiner harten Theile sich eng an *Osteolepis* anschliesst und aus " der Kohlenformation herstammt. Es ist der Genus *Megalichthys*, von dem wir leider " die Beschaffenheit und Lage seiner Flossen gar nicht kennen."—Pander, l. c., p. 5.

While the exoskeleton of *Megalichthys* is exceedingly similar to that of *Diplopterus* and *Osteolepis*, the endoskeleton presents a remarkable advance on that of any other Saurodipterine, in that both the centra and the neural arches of the vertebral column are thoroughly ossified. Excellent specimens of these vertebræ are to be seen in the British Museum.

The Saurodipterini and Glyptodipterini being thus separated from other Palæozoic fishes, as well-defined families, perfectly distinct from one another, though closely allied by the community of characters displayed in the number, structure and disposition, of their fins, the absence of branchiostegal rays and their replacement by jugular plates; we have next to consider what other families of fish, if any, should be ranged alongside of them, or in other words, what are the limits and what the importance of the larger group, formed by the association of these families.

In the first place, I conceive there can be no doubt that the CTENODODIPTERINI, a family justly established by Professor Pander* for the reception of *Dipterus* and its immediate allies, must take its place in close juxtaposition with the Saurodipterini and Glyptodipterini, seeing that it possesses all those structural peculiarities which are common to these two families. In fact, as Hugh Miller * originally pointed out in successive notices, *Dipterus* has the dorsal fins placed far back; acutely lobate pectorals and ventrals;† no branchiostegal rays, but jugular plates instead of them; and a single anal. The caudal extremity of the body tapers off to a point, and has the lower lobe of the fin very much larger than the upper; the scales are cycloid. Thus far, in fact, the definition of Ctenododipterini agrees with that of the Glyptodipterini; but the

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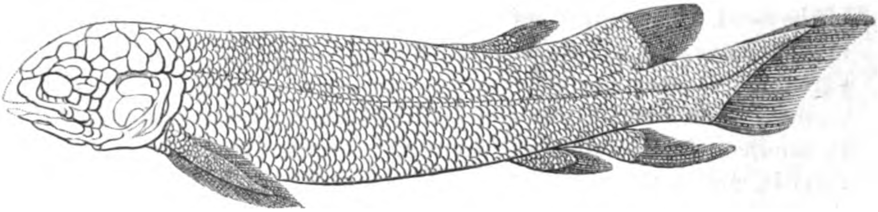
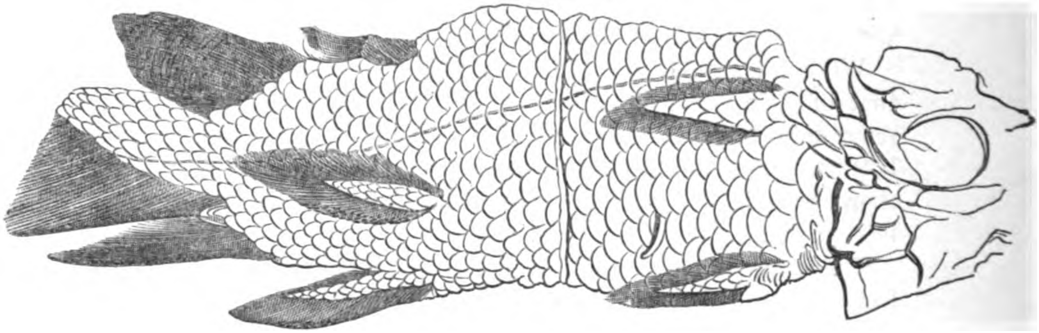
* Under the name of *Ctenodipterini*. Sir Phillip Egerton has, I think, given good reasons for the slight change I have adopted. *Vide infrà*, p. 55.

Fig. 9.



Restoration of *Dipterus* (after Pander).

Fig. 10.‡



Dipterus.

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* *See* "Old Red Sandstone," "Footprints of the Creator," and "Sketch Book of Popular Geology." It is much to be regretted that Professor Pander should have been wholly unacquainted with these works when he wrote his Monograph on the *Ctenododipterini*, and that he has consequently inadvertently failed to do justice to the great merits of Hugh Miller, who made known almost the whole organization of *Dipterus*, and anticipated the most important part of Prof. Pander's labours in this field.

† *See* Prof. Pander, l. c.

‡ The woodcut, fig. 10, represents the same specimen as that figured by Sir Philip Egerton in "Siluria," ed. 2, p. 287, but of the natural size. It exhibits the characters of the paired fins of *Dipterus* remarkably well.

former differ from the latter in the smoothness of their scales; in the structure of the roof of the cranium, whose constituent bones are anchylosed into a singular shield, presenting some resemblance to the cephalic shield of *Accipenser;* and lastly, and chiefly, in the peculiar form of the lower jaw, which much resembles that of a Cœlacanth, and in their dentition, so well made known by Hugh Miller, whose researches have been fully confirmed by Professor Pander.

In the next place, the true CŒLACANTHINI have a no less well-defined right to occupy a similar position.* I say the *true* Cœlacanthini, because the term "Cœlacanth" has been used by different palæontologists with such very different meanings, has been made in some cases to include so much, and in others to include so little, that I feel it to be necessary to define precisely the sense in which I employ it here. I intend it, then, to designate that family of fishes of which the genus *Cœlacanthus* of Agassiz is the type, a family which, thus restricted, is as well defined and natural a group as any in the animal kingdom, but, at present, can embrace only the genera *Cœlacanthus, Undina,* and *Macropoma.*

In order to make this clear, however, I must enter at some length into a historical and anatomical criticism of the Cœlacanths as a family of fishes.

In establishing this family ("Recherches," vol. ii. p. 168), Professor Agassiz dwells particularly upon the hollow fin rays of the typical genus; the absence of joints in some part of the length of most of those fin rays; the presence of interspinous bones in the caudal fin; the continuation of the vertebral column between the two lobes of that fin, and the prolongation of the caudal extremity beyond it as a filamentary appendage. With *Cœlacanthus, Undina, Macropoma, Hoplopygus, Uronemus, Holoptychius, Glyptosteus, Glyptolepis, Psammolepis, Phyllolepis, Ctenolepis,* and *Gyrosteus* are associated; and it is a curious circumstance that while *Holoptychius* takes its place among the Cœlacanths, without any special demonstration of its right to that position, Professor Agassiz hesitates touching *Macropoma,* and, while admitting it into the family on account of the striking analogy of its general physiognomy, and of the form, arrangement, and structure of its fins, adds: "I must " admit that side by side with these resemblances, the two types " exhibit profound differences," . . . " which will perhaps, in " the long run, necessitate another arrangement."

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* Several years ago Sir Philip Egerton strongly drew my attention to the close affinity between the *Cœlacanthini* (*mihi*) and what I have termed the *Glyptodipterini,* particularly showing the importance of the lobate paired fins and of the double dorsals common to the genera of both families (which Sir Philip Egerton was inclined to group under the one head of '*Cœlacanths*'), and illustrating his views by a synopsis of the genera. From the study of that synopsis I trace the gradual clearing up of my own ideas respecting the difficult subject with which this preliminary essay attempts to deal.

The idea that *Cœlacanthus* inclined more to *Holoptychius* than to *Macropoma,* appears to have found still more favour with Professor Agassiz at the time of the publication of his great work on the Fishes of the Old Red Sandstone; and the consequences of this inclination were the more important from the fact, that Agassiz held that the teeth, properly distinguished by Professor Owen under the name of *Rhizodus,* belonged to *Holoptychius.* For *Glyptolepis* and *Platygnathus* were undoubtedly closely allied to *Holoptychius,* while *Dendrodus, Lamnodus,* and *Cricodus* had much in common with *Rhizodus;* hence, as these dendrodont teeth were conceived by Agassiz to belong to the fish whose bony plates and scales had received the names of *Asterolepis, Bothriolepis,* &c., it was natural that he should include all these genera under the common title of "Cœlacanths;" while *Macropoma* and *Undina* were regarded with doubt, and, in fact, almost excluded from the group (" Vieux Grès Rouge," p. 64).

Here, however, I cannot but believe, that the founder of fossil ichthyology has, for once, gone off upon a wrong scent. For later investigations have made it, to say the least, extremely improbable that *Asterolepis* (Ag. & Miller) has anything to do with *Cricodus,* or with *Holoptychius,* whatever may be the relation of the two latter genera; and I shall now endeavour to prove that, while *Cœlacanthus* is so intimately connected with *Undina* and *Macropoma,* as to render the generic distinction of the three forms a matter of minute detail, its relations with *Holoptychius,* although clear and distinct so far as they go, are, at most, those of a member of the same suborder.

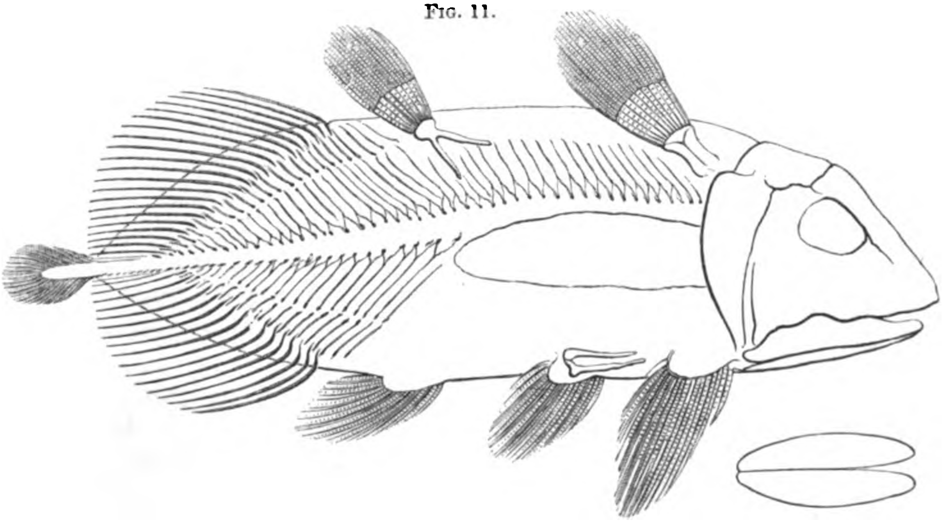
But first, what are the characters of the genus *Cœlacanthus?* This question is by no means so easily to be answered as might be imagined, but the following facts appear to furnish a conclusive reply to it.

The type species of *Cœlacanthus,* that on which the genus was founded by Agassiz, is the *C. granulatus* of the Magnesian Limestone; two figures of which are to be found in the " Recherches," while a third, representing another specimen, is given by Sir Philip Egerton in King's " Permian Fossils." Singularly enough, neither of these specimens retains its head, nor are the paired fins preserved;

but the characters of the spinal column, of the median fins, of the scales, and of the tail, are so exactly those exhibited by the *Undina* of Münster (of which sundry complete specimens exist), that the very close affinity of the two genera is beyond doubt. Agassiz, in fact, proposes to distinguish them only by their teeth; *Cœlacanthus* having, in his opinion, conical and recurved, while *Undina* has flat, pavement-like and tuberculated teeth. That Münster was correct in assigning such teeth to *Undina* I have satisfied myself by the examination of a well-preserved specimen of *U. Köhleri* in Lord Enniskillen's collection; but what evidence is there that *Cœlacanthus* has a different dentition? Agassiz was led to believe that the teeth of the latter genus are conical, by the fact that the specimen of a fish named by him *C. Münsteri* has such teeth. I am again indebted to the Earl of Enniskillen, of whose collection this specimen forms a part, for the opportunity of verifying the statement; but I must at the same time express my entire concurrence in the opinion previously expressed to me by Sir Philip Egerton, that the so-called "*Cœlacanthus*" *Münsteri* is not a *Cœlacanthus* at all.

For, as I have stated above, there can be no doubt that *Cœlacanthus* (*C. granulatus* being the typical species) was, in all the great features of its organization, similar to *Undina*; so that, contrariwise, any fish which differs in essentials very widely from *Undina* can be no *Cœlacanthus*.

FIG. 11.



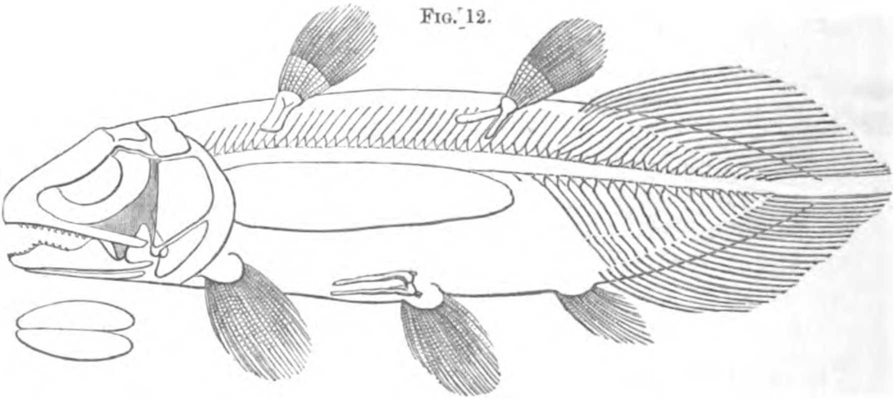
Restoration of *Undina*. (Partly after Münster, partly from Lord Enniskillen's specimen. Below the head are the contours of the jugular plates.)

But *Undina* has two dorsal fins, each supported by but a single, very peculiarly shaped, interspinous bone; it has a large caudal fin, whose rays are supported by interspinous bones, and which is divided into two equal lobes by the unossified spinal column; the latter extending beyond the caudal fin as a tufted appendage, or second caudal, provided with very short fin rays. There is a single anal fin; the pectoral and ventral fins are well developed and obtusely lobate; the pelvic bones are remarkably large, and are united together by transverse branches, which extend from the posterior extremities of each and meet in the middle line; there are no dorsal ribs and no proper branchiostegal rays, but instead of them, two broad principal jugular plates. Finally, the scales, large, thin and cycloid, are ornamented with elongated splashes and dots of enamel. On the other hand, "*Cœlacanthus*" *Münsteri* exhibits no one of the positive characters here enumerated, while it *has* ribs attached throughout the dorsal region; in fact, I am inclined to consider it the type of a new genus allied to *Phaneropleuron*.

I have seen no specimens of the other species of *Cœlacanthus* enumerated by Agassiz, and I can therefore say nothing about them. But *Cœlacanthus caudalis* (Egerton) is a true Cœlacanth, as I have convinced myself by examination of the specimen, to which the figure in King's "Permian Fossils" does not quite do justice.

As the case stands, then, it appears that there is no evidence that the supposed distinction between *Cœlacanthus* and *Undina* really obtains; while, on the other hand, a recent careful comparison of well-preserved specimens of *Undina* and of *Macropoma* has convinced me that these two genera are not much less closely allied.

FIG. 12.



Restoration of *Macropoma*.

All the structural characters, in fact, which have been enumerated above among the peculiarities of *Undina*, are equally well marked in *Macropoma*, except that, hitherto, I have been unable to meet with the caudal appendage in the latter, and that the teeth are more distinct and cylindrical. But further than this, as Dr. Mantell originally suspected, and as Professor Williamson has since demonstrated, *Macropoma* exhibits the peculiarity, without a parallel, so far as I know, among fishes of other families, of having the walls of its air bladder ossified. Now, I find good evidence of the existence of a similarly ossified air bladder, not only in *Undina*, but in a well-preserved specimen of a new genus of Cœlacanth from the Lias (described in the subjoined note by Sir Philip Egerton), in the Museum of Practical Geology.*

* *Holophagus Gulo.*

Mr. Harrison's specimen wants the anterior portion from the dorsal and pectoral fins forwards. From the insertion of the dorsal fin to the extremity of the tail it measures 11½ inches, and 4½ inches in depth. The stomach is distended with a recently swallowed *Dapedius*, and a large coprolite occupies the rectum. The first dorsal fin springs (as in *Macropoma*) from a single disc, resulting from the coalescence of the interneural spines. It contains eight long, thick, undivided, and multiarticulate rays. They are beset with numerous short spines or tubercles. The second dorsal is situated 4 inches behind the first. Between the two is seen a strong bifurcate interneural ossicle, which has been displaced forwards from its proper position at the base of the fin. The second dorsal fin contains sixteen rays. The anterior ones are short and slender. The succeeding ones are long, broad, and multiarticulate, but not tuberculate. The base of the fin is obtusely lobate, with a scaly investment. The pectoral fins are much mutilated. Judging from what remains of them, and from some indistinct impressions, they seem to have been of great size. The anal fin occurs immediately below the second dorsal fin, with which it corresponds in form and structure, but contains many more rays. The ventral fins are mutilated, but their position below the first dorsal fin is indicated by the preservation of a pair of strong T-shaped pelvic bones, having their longer limbs directed forwards, and nearly reaching the base of the pectoral fins. The caudal fin is of great size, and presents in an eminent degree the most special and characteristic feature of the *Cœlacanthus* family, namely, the interposition, in the caudal region, of an interneural between the neural and dermo-neural spines. The base of this spine abuts upon the extremity of the neural spine, and unites with the true fin-ray by an overlap or splice. This structure coincides with that observed in *Undina*. In *Macropoma* the bone of the interneural spine is bifurcate for the reception of the distal extremity of the neurapophysis. A small supplemental fin extends an inch beyond the larger caudal fin, as in *Undina* and *Cœlacanthus*. The notochord is unossified. The apophyses, both above and below, have very wide bases. The scales are curvilinear, and covered with a vermiculate pattern on the upper surface, occasionally broken up into small tubercles.

In the Woodwardian Museum at Cambridge there is the head and part of the trunk of a *Cœlacanthus*, from the Kimmeridge Clay at Cottenham. The head shows the frontals, prefrontals, and lower jaw, with the tympanic attachments. The glossohyal plate is double, as in *Holoptychius*. The scales are roughly undulate, coarser in pattern than in *Undina*, *Cœlacanthus*, and *Holophagus*, but not absolutely tuberculate, as in *Macropoma*. One fin is preserved, probably the left pectoral. It is lobate, broad, and strong. The operculum is triangular, the frontals short, and the prefrontals descend at an abrupt inclination.

Thus, leaving open the question as to the identity of *Cœlacanthus* with *Undina*, and also that whether *Uronemus* and *Hoplopygus* (which I have not seen, and concerning which no details are given by Agassiz) are Cœlacanths, or not; it appears to be certain that fishes closely allied to *Cœlacanthus granulatus*, and known under the generic appellations of *Undina* and *Macropoma*, form an exceedingly well-defined family, to which the term CŒLACANTHINI may with propriety be restricted, and which has ranged in time, with remarkably little change, from at least as early as the Permian formation to the Chalk, inclusive.

The Cœlacanthini, as thus understood, are no less distinctly separated from other fishes than they are closely united to one another. In the form and arrangement of their fins; the structure of the tail and that of the cranium; the form and number of the jugular plates; the dentition; the dorsal interspinous bones; the pelvic bones; the ossified air bladder; the Cœlacanthini differ widely from either the Saurodipterini, the Glyptodipterini, or the Ctenododipterini; but, on the other hand, they agree with these families and differ from almost all other fishes, in the same respects as those in which the several families just mentioned, have been shown to agree with one another; viz., the number of the dorsal fins, the lobation of the paired fins, the absence of branchiostegal rays, and their replacement by jugular bones.

Their special affinities among these three families appear to me to lie chiefly with the Ctenododipterini: the scales, the arrangement of the teeth, and the form of the lower jaw in the two families presenting many curious analogies.

The Glyptodipterine family contains, as we have seen, both cycliferous and rhombiferous genera. Following out the alliances of the former subfamily, we have found reason to include the cycliferous Ctenododipterini and the cycliferous Cœlacanthini in the same larger, or subordinal, group with the Glyptodipterini. If, on the other hand, we now trace out the congeners of the rhombiferous subfamilies, we arrive, as has been seen, at the Saurodipterini; and the question now remains, what other rhombiferous Ganoids naturally arrange themselves at this end of the series?

So far as I am aware, there is no other fossil rhombiferous Ganoid which comes within the scope of the sum of characters common to the Saurodipterini, Glyptodipterini, Ctenododipterini, and Cœlacanthini; but among recent fishes there is one, *Polypterus*, which very nearly approaches the required standard, and is unquestionably closely allied to the Saurodipterini.

Polypterus, in fact, has an elongated body, with a depressed head, and a conically tapering caudal extremity. The orbits are situated in the fore part of the head, while the gape extends far back. There are two large principal jugular plates, without lateral or median plates. The pectoral arch is covered inferiorly by two triangular osseous plates, which meet in the middle line, and are superficial to the so-called coracoids. The pectoral and ventral fins are lobate. The caudal fin is rhomboidal and nearly diphycercal.*

FIG. 15.

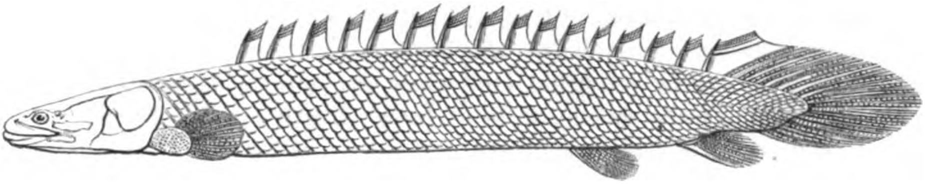


Figure of *Polypterus* (after Agassiz).

A comparison of these characters with those which have been assigned to *Glyptolæmus*, or to *Osteolepis*, reveals at once the close connexion of the three genera,† from which however *Polypterus* differs in many important particulars.

Thus the parietal bones of *Polypterus* are much smaller, in proportion to the frontals, than are those of either *Osteolepis* or *Glyptolæmus*, and with age they unite with one another and with

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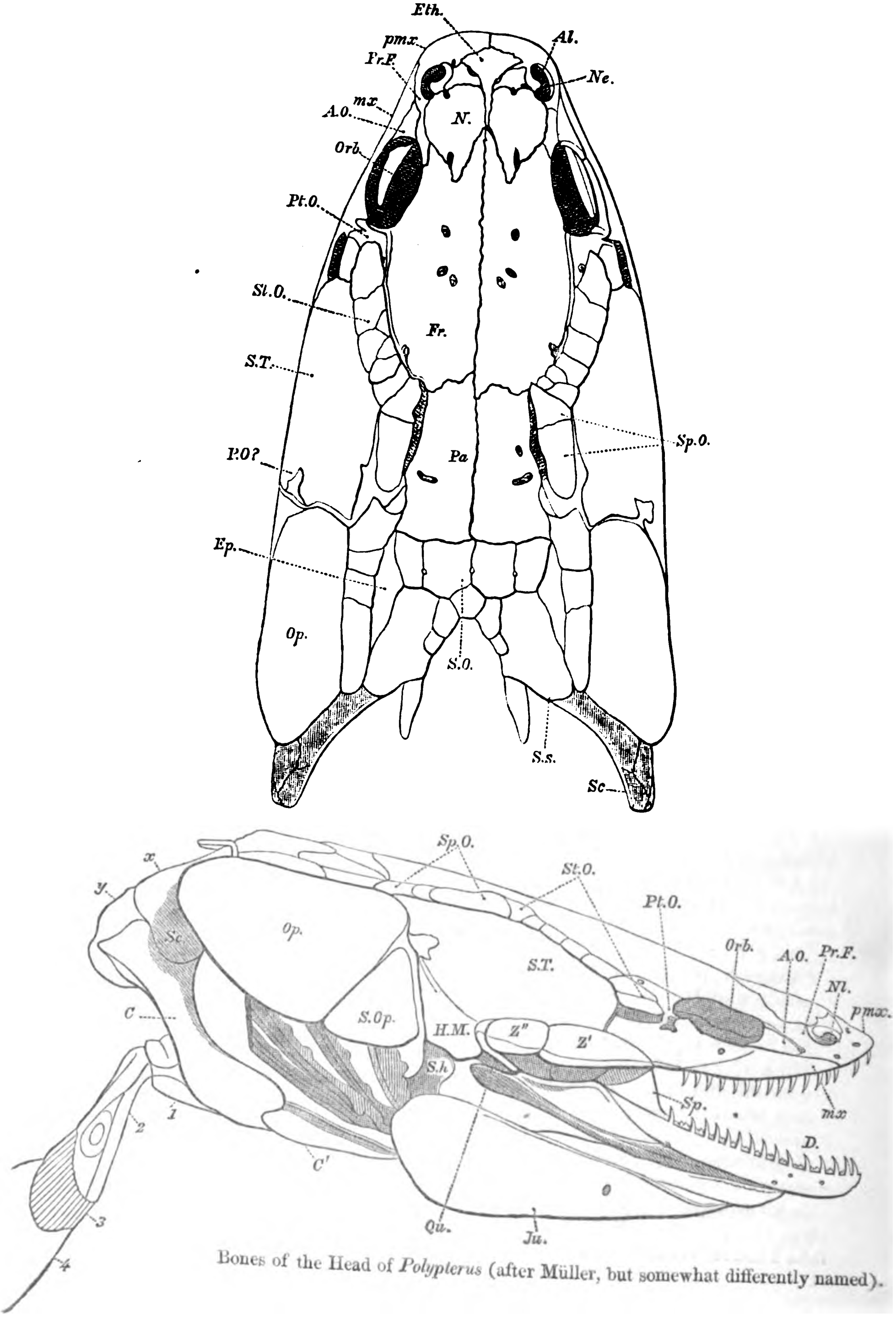
* *See* the careful account of the tail of *Polypterus*, by Kölliker, "Ueber das Ende der Wirbelsäule der Ganoiden."

† I do not know that any one has hitherto pointed out in detail the very close relation between *Polypterus* and the fossil genera enumerated above; but Professor Pander has enunciated conclusions nearly similar to my own in the following passage (Ctenodipterinen, p. 3.) :—

"Ueberhaupt ist es merkwurdig zu sehen wie *Polypterus* so ganz in den Hintergrund
" gestellt wird, Herr J. Müller (Ueber d. Bau.) sagt ausdrücklich 'Fur den *Polypterus*
" 'kenne ich unter allen fossilen Ganoiden keine analogie.' Und Herr Pictet wieder-
" holt dasselbe gleichfalls, 'aucun fossile n'a été rapproché de ce genre remarquable.'
" Wir werden in Zukunft sehen dass wenn man überhaupt ein Recht hat, wie es doch
" wahrscheinlich ist, die ausgestorbenen Geschlechter der Devonischen Formation jetzt
" noch lebenden Fischen an die Seite zu stellen, mehrere durch ihre Zahnbau, durch die
" grossen Knochen-platten und die Stelle der Kiemenhaut-strahlen, durch den Bau der
" Kopfknochen, u.s.w., eine grössere analogie mit dem *Polypterus* als seinen Amerika-
" nischen Zeitgenossen besitzen."

In his subsequent memoirs Prof. Pander has not followed out to their logical result the views so sagaciously indicated in this paragraph, which I think would be identical with those I had arrived at before I read it, and now publish.

Figs. 16 and 17.



Bones of the Head of *Polypterus* (after Müller, but somewhat differently named).

the frontals, into a continuous shield, as seems to have been the case in *Dipterus*.

The upper part of the occipital region is covered by a number of more or less irregular plates, which, however, may be readily shown to correspond with dismemberments of the three plates found in the Saurodipterini, &c. There are neither lateral, nor median, jugulars; the teeth have simple pulp cavities; and what is most remarkable, the dorsal fin, instead of being double, is incompletely broken up into a number of pinnules, which extend for nearly the whole length of the back. Furthermore, *Polypterus* has a spiracle, a structure of which I find no trace in any of the fossil genera.

It may conduce to clearness if, before proceeding farther, I now endeavour to put the results of the preceding statements into a readily comprehensible and definite form, and show their bearing upon the classification of the Ganoids, and more particularly upon that of the fossil Ganoidei. To this end I have prepared the following synoptical table:—

Ordo GANOIDEI.

Subordo I.—Amiadæ.

Subordo II.—Lepidosteidæ.

Subordo III.—Crossopterygidæ.

Fam. 1.—Polypterini.

Dorsal fin very long, multifid; scales rhomboidal.
Polypterus.

Fam. 2.—Saurodipterini.

Dorsal fins two; scales rhomboidal, smooth; fins subacutely lobate.
Diplopterus, *Osteolepis*, *Megalichthys*.

Fam. 3.—Glyptodipterini.

Dorsal fins two; scales rhomboidal or cycloidal, sculptured; pectoral fins acutely lobate; dentition dendrodont.

Sub-fam. A. with rhomboidal scales.
Glyptolæmus, *Glyptopomus*, *Gyroptychius*.

Sub-fam. B. with cycloidal scales.
Holoptychius, *Glyptolepis*, *Platygnathus* [*Rhizodus*, *Dendrodus*, *Cricodus*, *Lamnodus*].

Fam. 4.—Ctenododipterini.

Dorsal fins two; scales cycloidal; pectorals and ventrals acutely lobate; dentition ctenodont.

Dipterus, [*Ceratodus? Tristichopterus?*].

Fam. 5.—Phaneropleurini.

Dorsal fin single, very long, not subdivided, supported by many interspinous bones; scales thin, cycloidal; teeth conical; ventral fins very long, acutely lobate.

Phaneropleuron.

Fam. 6.—Cœlacanthini.

Dorsal fins two, each supported by a single interspinous bone; scales cycloidal; paired fins obtusely lobate; air bladder ossified.

Cœlacanthus, Undina, Macropoma.

Subordo IV.—Chondrosteidæ.

Subordo V.—Acanthodidæ.

Considering the Ganoidei, as defined by Müller, to form an order of the class *Pisces*, and adopting the four groups typified by *Amia*, *Lepidosteus*, *Accipenser* and *Acanthodes*, respectively, as suborders, without thereby prejudicing the question as to whether other suborders may not be required, I propose to establish another and equivalent group, or suborder, to comprise the existing *Polypterus* and all those extinct Ganoids which, like it, fall within the range of the following definition:—

Dorsal fins two, or, if single, multifid or very long; the pectoral and usually the ventral fins, lobate; no branchiostegal rays, but two principal, with sometimes lateral and median, jugular plates, situated between the rami of the mandible; caudal fin diphycercal, or heterocercal; scales cycloid or rhomboid, smooth or sculptured.

On the suborder thus defined I propose to confer the title of CROSSOPTERYGIDÆ,* in consideration of the peculiar manner in which the fin rays of the paired fins are arranged, so as to form a fringe round a central lobe, which constitutes so marked a character of all the genera belonging to the group at present known.

The characters of five of the six families which compose this suborder have been given, incidentally, in the preceding pages, but the table contains another family whose collocation with the rest requires justification.

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* κροσσωτὸς, πτέρυξ, "fringed fin." "Crossotopterygidæ" would perhaps be more correct, but the shorter compound is preferable.

This is the family of the PHANEROPLEURINI, which I have established to contain the singular genus *Phaneropleuron*, described at length in this Decade (p. 47) and figured in Plate III. The general character of this fish, its thin cycloid scales, the mode of termination of its caudal extremity, and its remarkable, very acutely lobate, ventral fins, lead me to entertain very little doubt that its right place is among the Crossopterygidæ, and in the neighbourhood of the Glyptodipterini and Cœlacanthini, though I have not yet been able to obtain a very good view of its jugular plates. But the very long, single, dorsal fin, the great length and acute lobation of the ventral fins, which seem to have been longer than the pectorals, and the complete ossification of the costal elements and neural arches throughout the vertebral column, separate *Phaneropleuron* alike from the Glyptodipterini and the Cœlacanthini. From the Ctenododipterini it is separated not only by these characters, but by its dentition. Under these circumstances the only course seems to be to regard it as the type of a distinct family.

The group of Crossopterygidæ, as thus established, appears to me to have many remarkable and interesting zoological and palæontological relations. Of the six families which compose it, four are not only Palæozoic, but are, some exclusively and all chiefly, confined to rocks of Devonian age,—an epoch in which, so far as our present knowledge goes, no fish belonging to the suborders of the Amiadæ or Lepidosteidæ (unless *Cheirolepis* be one of the latter) makes its appearance. Rapidly diminishing in number, the Crossopterygidæ seem to have had several representatives during the Carboniferous epoch, but after this period (unless *Ceratodus* be a Ctenododipterine) they are continued through the Mesozoic age only by a thin, though continuous, line of Cœlacanthini, and terminate, at the present day, in the two or three known species of the single genus *Polypterus*. *Polypterus*, however, is clearly related to the rhombiferous Crossopterygians, or in other words, to exactly that group of whose existence we have no knowledge in any Mesozoic, or Tertiary, formation; while the Ctenododipterini and Cœlacanthini, which depart most widely from *Polypterus*, are those which continue the line of the Crossopterygidæ from the Palæozoic to the end of the Mesozoic epoch. Thus both ends of the Crossopterygian series appear, if I may use the expression, to be cut off from the modern representatives of the suborder; *Polypterus* being separated from those members of its suborder with which it has the closest zoological relations, by a prodigious gulf of time, and from the fossil allies which are nearest to it in time, by deficient zoological affinity.' I may make my meaning more intelligible by a diagram, however.

PALÆOZOIC.

Ctenododipterini, *Phaneropleurini*, *Glyptodipterini*, *Saurodipterini*,
Cœlacanthini.

MESOZOIC.

Cœlacanthini.

TERTIARY.

RECENT.

Polypterini.

Here it is obvious that, in time, the Polypterini are twice as remote from their immediate zoological affines, the Saurodipterini and Glyptodipterini, as they are from their more distant connexions, the Cœlacanthini.

It seems singular that while the line of the rhombiferous Crossopterygidæ has so distinct a modern representative, the cycliferous Crossopterygidæ seem to have died and left no issue at the end of the Tertiary epoch. But without wishing to lay too much stress upon the fact, I may draw attention to the many and singular relations which obtain between that wonderful and apparently isolated fish, *Lepidosiren*, sole member of its order, and the cycloid Glyptodipterine, Ctenododipterine, Phaneropleurine, and Cœlacanth Crossopterygidæ. *Lepidosiren* is, in fact, the only existing fish whose pectoral and ventral members have a structure analogous to that of the acutely lobate, paired fins of *Holoptychius*, of *Dipterus*, or of *Phaneropleuron*, though the fin rays and surface scales are still less developed in the modern than in the ancient fish. The endoskeleton of *Lepidosiren*, again, is, as nearly as possible, in the same condition as that of *Phaneropleuron*, and is more nearly similar to the skeleton of the Cœlacanths than that of any other recent fish; while, perhaps, it is not stretching the search for analogies too far to discover in the

FIG. 18.

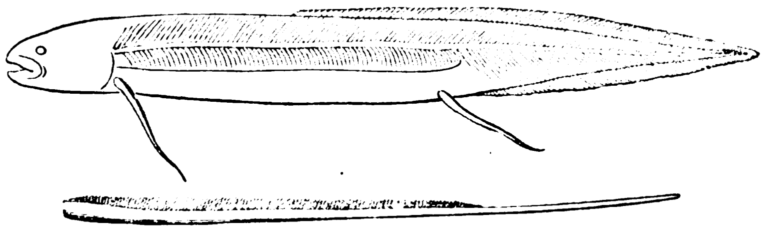

Diagram of *Lepidosiren*. (The lower figure represents the pectoral fin on a larger scale.)

stiff-walled lungs of *Lepidosiren*, a structure more nearly representing the ossified air bladder of the Cœlacanths than any with which we are at present acquainted, among recent or fossil fishes. Furthermore, *Lepidosiren* is the only fish whose teeth are comparable in form and arrangement to those of *Dipterus*.* Though *Lepidosiren* may not be included among the Crossopterygidæ, nor even in the order of the Ganoidei, the relations just pointed out are not the less distinct; and, perhaps, they gain in interest when we reflect, that while *Polypterus*, the modern representative of the rhombiferous Crossopterygidæ, is that fish which has the most completely lung-like of all air bladders, *Lepidosiren*, which has been just shown to be, if not the modern representative of the cycliferous Crossopterygidæ, yet their "next of kin," is the only fish which is provided with true lungs. These are unquestionable facts. I leave their bearing upon the great problems of zoological theory to be developed by every one for himself.

The preceding discussion of the affinities of the Devonian genera, *Osteolepis, Diplopterus, Glyptolæmus, Glyptopomus, Gyroptychius, Holoptychius, Glyptolepis, Dendrodus, Phaneropleuron, Dipterus*, was an indispensable preliminary to the consideration of the main question with which I proposed to deal in the present essay, viz., What, and how many, groups of fishes are represented in the Fauna of the Devonian epoch? a Fauna which presents a surpassing interest, when we recollect that it comprises the oldest assemblage of vertebrate animals, of which we possess a more than fragmentary knowledge; that its constituents abound in certain localities; and that, for many years past, they have been the subject of careful and repeated collection and investigation. An examination of the data collected up to the present time has led me to the following conclusions, some of which are already current, while others are new:—

1. No vertebrate animal higher in the scale than fishes is as yet certainly known to have been found in any rock of Devonian age. In fact, until demonstrative stratigraphical evidence of the Devonian age of the well-known Elgin beds is obtained, the bearing of the palæontological evidence against that conclusion is too strong to allow of its being entertained.

2. Of the six orders of the class Pisces, three, namely, the DIPNOI, MARSIPOBRANCHII, and PHARYNGOBRANCHII, are certainly not represented by any known Devonian fish. In endeavouring to estimate the value of this negative fact, we must recollect that no fish

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* Prof. Pander has drawn attention to the resemblance of the teeth of his genus *Holodus* to those of *Lepidosiren*, but it is not clear that he regards *Holodus* as a Ctenodipterine.

belonging to either of these orders is at present known in the fossil state; that they are represented by a very small number of genera and species in our existing Fauna; finally, that the Pharyngobranchii, from their very nature, could hardly be preserved in a recognizable state, even in such fine mud as that of the Oxford clay, or the Solenhofen slates; and that of the Marsipobranchii nothing but the horny teeth could be expected to escape destruction. *Lepidosiren*, on the other hand, might have left as definite traces of its existence as *Dipterus*, and hence its entire absence in the fossil state is a negative fact of greater value.

3. The ELASMOBRANCHII abounded, teeth and spines testifying to the numerous and diverse genera which haunted the Devonian seas. It is more difficult to say to what sections of the order these genera belonged, as the only Devonian Elasmobranch whose whole structure can be restored with any certainty is *Pleuracanthus*, a fish which belongs to a family distinct from any now living.

4. The GANOIDEI, as I have endeavoured to show above, are largely represented by a suborder, the Crossopterygidæ, which drops into comparative insignificance in later ages. Of the existence of Amiadæ there is no evidence, and even if we include *Tharsis*, *Thrissops*, and *Leptolepis* under this suborder, they are scanty in all later formations; but what is much more remarkable is the apparent, entire, or almost entire, absence of the Lepidosteidæ, a suborder which obtains such a prodigious development in the Mesozoic epoch. The nature of the Acanthodidæ, and the question whether there is any reason to suspect the existence of Chondrostei during the Devonian epoch will be considered by-and-bye.*

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* The determination of the characters of the families of Lepidosteidæ and of the limits of the suborder is a difficult problem, of which I hope to treat more fully hereafter. One interesting fact results from my investigations, so far as they have hitherto gone, viz., that *Lepidosteus* belongs to a totally distinct family from its Mesozoic allies, whether "Sauroids" or "Lepidoids." The Pycnodonts and Hoplopleuridæ do not appear to me to belong to the Lepidosteidæ, and I doubt their being true Ganoids. For the present I propose the following as a sketch of an arrangement of the Lepidosteidæ.

LEPIDOSTEIDÆ.
  Heterocercal Ganoids with rhomboidal scales; branchiostegal rays; non-lobate paired fins; a preoperculum and an interoperculum.
Fam. 1. Lepidosteini.
  Maxilla divided into many pieces; branchiostegal rays few and not enamelled.
    Lepidosteus.
Fam. 2. Lepidotini.
  Maxilla in one piece; branchiostegal rays many and enamelled; the anterior ones taking the form of broad plates.
    (a) *Œchmodus*, *Tetragonolepis*, *Dapedius*, *Lepidotus*, *&c.*
    (b) *Eugnathus*, *Pachycormus*, *Oxygnathus*, *&c.*
    (c) *Aspidorhynchus.*
  Perhaps the genera marked a, b, c, should form distinct sub-families.

5. The TELEOSTEI have hitherto been supposed to be entirely absent from formations of Palæozoic age, and no doubt they do not exist under those forms which are most familiar to ichthyologists acquainted with marine fishes, or with the fresh-water fishes of temperate climates; but, nevertheless, I shall now endeavour to show that there are grounds for something more than a suspension of judgment, as to the validity of the ordinary doctrines held upon this subject.

The remarkable genera *Coccosteus* and *Pterichthys* are those which, among all Devonian fishes, have been by common consent regarded as the most heteroclite and anomalous, some writers having gone so far, in fact, as to imagine that these hard cased vertebrates offered us a transition to the shelled Invertebrata.

Nevertheless, I trust I shall be able to show that the one of these two closely allied genera—*Coccosteus*—is best, indeed, I may say only, to be understood, by comparing its bony shields with those which cover the roof of the cranium and the anterior part of the body of certain existing Siluroid Teleosteans.

To this end, however, I must first give the conception of the structure of *Coccosteus* which my own investigations, guided by those of my predecessors Agassiz, Miller, Egerton, and Pander,* have led me to form.

The superior wall of the skull only, seems to have been ossified in this fish, and forms a great shield, which may be roughly said to have a hexagonal figure. The posterior and postero-lateral sides of the hexagon are pretty nearly straight lines, while the anterior side is rounded off, to form the snout, and the antero-lateral sides, the longest of all, have their anterior moieties deeply excavated, to constitute the upper part of the walls of the orbit. From before backwards, in the median line, the contour of the cranial shield is nearly straight, but from side to side it is convex, in consequence, more particularly, of the downward inflexion of its postero-lateral angles. The sutures, which separate the various constituent bones of the skull, may readily be confounded with certain superficial grooves of a totally different import, but, by grinding away the outermost layer of bone, this source of error is avoided; and it is then seen that the cranial sutures have the arrangement represented in the woodcut, fig. 19, and define the several bones from one another with great sharpness.

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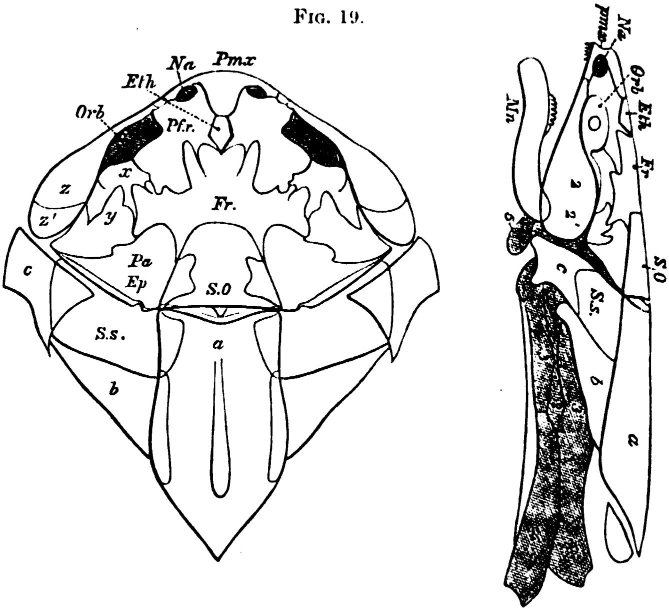
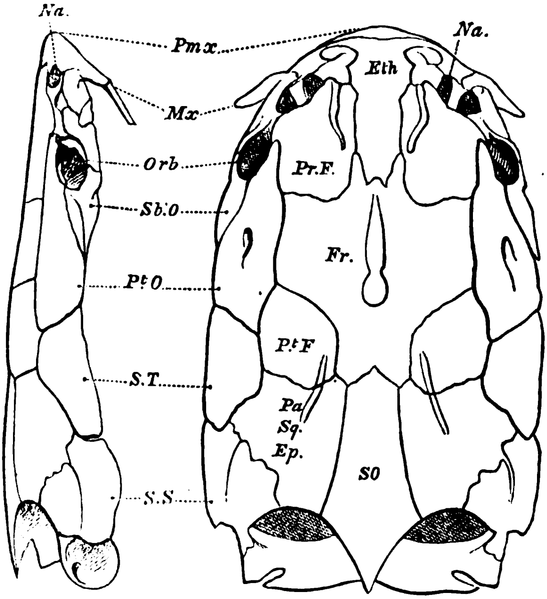
* Compare Agassiz, "Monog. des Poissons Fossiles du Vieux Grès Rouge;" H. Miller, "Old Red Sandstone" and Quart. Jour. Geol. Soc. 1859; Pander, "Ueber die Placodermen des Devonischen Systems, 1857;" Sir P. Egerton, "Remarks on the Nomenclature of the Devonian Fishes," Quart. Jour. Geol. Soc. 1859.

FIG. 19.



Bones of the head and of the cuirass of *Coccosteus.*

FIG. 20.



Bones of the head of *Clarias.*

In the middle line, behind, they mark off a symmetrical, trapezoidal bone, S.O., which presents a short peg-like process in the middle of its posterior edge, and has a peculiar raised pattern upon its under surface. In front, this bone is articulated with the singular four-rayed bone Fr. The posterior ray (with which S.O. is connected) is the shortest and broadest of the four, while the lateral rays are the longest and the narrowest, the anterior ray holding a middle position in this respect. The edges of the anterior and of the lateral rays are variously indented, apparently to form an interlocking suture with the adjacent bones, while the posterior ray is deeply excavated to unite with S.O. A third bone, much smaller than the preceding, succeeds them anteriorly, and appears to be separated by a transverse suture from a fourth median bone (Pmx.), whose rounded free edge forms the anterior contour of the snout. In well-preserved specimens, this edge is seen to be beset with small, projecting, spine-like tubercles or teeth. The lateral portions of the skull are constituted, proceeding as before, from behind forwards, as follows: a triangular bone (Pa. Ep.), one of whose sides, directed outwards and backwards, forms the postero-lateral side of the hexagon above referred to, unites, by its inner edge, with the bone S.O., and, by its anterior edge, partly with Fr. and partly with another bone (*y*). These edges are irregularly sinuous, and form a squamous suture with the neighbouring bones. The posterior edge of Pa. Ep. presents, near its inner extremity, a sort of socket, with which a peg developed from the plate S.s. is articulated.

An irregularly triangular bone (*y*) is connected with the anterior edge of Pa. Ep., and forms the posterior angle and part of the antero-lateral edge of the skull. It is succeeded by another irregular bone (*x*), which enters into the posterior and upper wall of the orbit, and unites internally with Fr., and anteriorly with a larger and still more irregular bone Pfr. The latter is connected internally with Fr., Eth. and Pmx.; while externally it sends off, rather in front of the middle of its length, a short process, which passes directly downwards and divides the orbital cavity (Orb.) from the nasal cavity (Na.) Extending from the lower end of this process to the postero-lateral angle of the skull, bounding the orbit below, and fitting in by its convex margin, to a concave excavation of the bones *x*, *y*, is a large spatulate bony plate, narrow in front, broad and expanded behind, and composed of two pieces, *z* and *z′*.

The cranio-facial shield thus composed is succeeded by an osseous girdle, which defended the anterior part of the body like the back and breastplates of a mediæval warrior, and is divisible into two portions, the dorso-lateral and the ventral shields—the former composed of nine pieces, the latter of six. Of the nine pieces of the dorso-lateral shield, seven are closely articulated together, while the other two, small and comparatively insignificant, (and not represented in the dorsal view, fig. 19) were placed loosely at the sides of the posterior end of the great median plate of the seven. This plate *a* corresponds in width, anteriorly, with the cranial bone S.O.; it widens a little behind the middle of its length, and then rapidly tapers to a point. From the middle of its under surface it sends down a strong bony crest, deeper behind than in front, while its lateral edges overlap and unite, by a squamous suture, with the plates S.s. and *b*.

S.s. is a four-sided plate, articulated with Pa. Ep. in the manner before mentioned, while behind it overlaps the triangular plate *b*, and below is overlapped by the plate *c*. The latter is so constantly thrown out of its place in specimens where the connexion between *a*, *b* and S.s. is perfectly retained, that I suspect it rather overlapped than was suturally united with S.s.

The ventral shield appears to me to have had no direct connexion with the dorsal. I have examined a large number of specimens with reference to this point, but I have never discovered the least evidence of a sutural union between any two elements of the two shields, though the respective constituents of each shield are constantly met with in all stages of union and disunion. Of the elements of the ventral shield, two are median and symmetrical, four lateral and in pairs. The two latter, upon each side, are broad at their remote ends and narrower at their adjacent ends, whose outer edges are, besides, somewhat bent up. Of the median plates, the posterior is rhomboidal and articulates with all the others; the anterior has the form of an elongated isosceles triangle, whose base, directed anteriorly, is rounded off and forms the middle of the anterior margin of the ventral shield.

The stout, doubly curved, clavicle-like bones Mn., found, in complete specimens, on the under side of the head, have one edge beset with minute denticles for a short distance; and there are two other flat, elongated, bones, devoid of sculpture upon their outer surfaces. which lie between them and the anterior edge of the ventral shield.

Beside the parts now described, the only other bones known to belong to *Coccosteus* are the neural and subcaudal arches, the fin-rays and their supports, and the curved ossicles which lie just behind the body armour, and were perhaps connected with ventral fins; but I enter into no particular description of these, as they are not essential to my present purpose.

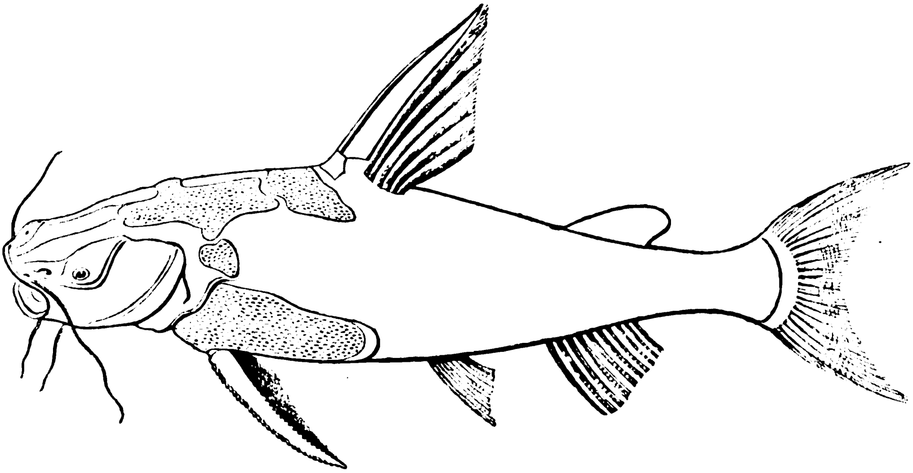
For some years past I had suspected that the modern Siluroids presented more analogies to the seemingly aberrant Devonian fishes than any other members of the class Pisces, and from the examination of dried specimens, I had even pitched upon the Siluroid genus *Clarias* as that most likely to help me to understand *Coccosteus;* but it was not until my friend and former pupil, Mr. J. J. Monteiro, brought home for me from Congo some specimens of *Clarias capensis* preserved in spirits, that I was able to examine the osseous structure of that fish with sufficient care and thoroughness for the purposes of an efficient comparison.

In fig. 20 a careful, reduced representation of the top of the skull of this fish is given, and it will be seen, that in everything but the minor details of form, it agrees with *Coccosteus.* The middle line of the skull is, as in the latter genus, occupied by three bones. S.O., the supra-occipital, is, in the recent form, pointed behind; Fr., the principal frontal, is, as in the fossil, four-rayed; it exhibits a considerable gap or fontanelle, but no median suture; Eth., the ethmoid, and Pmx., the premaxilla, correspond exactly in the two skulls, if we leave out of consideration the position of the suture seen in the fossil in this region. The bone Pr. F., which can be at once identified as the prefrontal in *Clarias*, and which sends down a process dividing the orbit from the nostril, obviously corresponds with the similarly related bone in *Coccosteus;* while in *Clarias* the orbit is completed below by the spatulate suborbital bone, Sb. O., smaller in proportion and undivided, but otherwise similar to the bone *z, z'* of *Coccosteus.* The post-orbital bone, Pt. O., and the supra-temporal bone, S. T., of the former appear to have their homologues in the bones *x* and *y* of the latter fish.

The space between the frontal, the supra-occipital, and the supra-temporal is occupied, in *Clarias*, by two bones, the anterior of which certainly represents the post-frontal; while the posterior occupies the situation of no less than three distinct bones in the heads of ordinary fishes, viz., the parietal, the squamosal, and the epiotic. The reduction in the normal number of bones which obtains in the Siluroid has been carried a step further in *Coccosteus*, where the plate lettered for shortness' sake only Pa. Ep. is the only representative of the bones Pt. F. and Pa. Sq. Ep. of *Clarias.*

Lastly, comes the bone S.s. naturally united in *Clarias* to Pa. Sq. Ep. and to S. T., and which corresponds with the supra-scapula of ordinary osseous fishes, in which it is usually connected with the skull only by ligament. The Siluroids and Ganoids, however, coincide in always having this bone more closely united with the regular cranial bones, and *Coccosteus*, it will be observed, agrees with them.

FIG. 20.

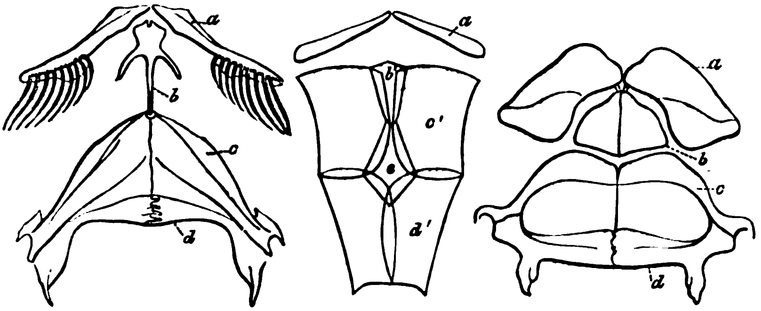


Arius rita, after Cuvier and Valenciennes.

So much for the cranial shield. To comprehend the dorsal and ventral body shields we must have recourse, not to *Clarias*, but to other Siluroids, such as *Bagrus*, *Arius*, &c. In these fishes, in fact, the anterior dorsal interspinous bones become so modified as to form a great shield-shaped dermal plate, with a strong inferior crest, which occupies the same position and has the same relations as the medio-dorsal plate of *Coccosteus*, though it commonly bears a strongly articulated spine, which is absent in the latter genus. In some species, as *Arius cruciger*, the principal plate is provided with lateral accessory plates, in which, perhaps, we have the homologues of the dermal plates *b*, of *Coccosteus*. It is possible that *c* may have been the operculum, which occupies a nearly similar position in *Arius*, but if it were suturally connected with the suprascapula, this view would be untenable, and the bone would have to be regarded as a scapular element.

In the Siluroids to which I have referred, and in *Loricaria*, a vast latero-ventral shield is produced by the prodigious expansion and coalescence of the bony elements which are homologous with those termed "coracoid" and "radius" in other fishes. Viewed from the ventral surface, these bones form four great plates, those of each side being closely united, or even amalgamated together, while the opposite pairs are joined, in the middle line, by a strongly serrated suture.

Fig. 21.



Hyoidean and Pectoral Plates of
Clarias. *Coccosteus.* *Loricaria.*

When the pectoral fin is provided with an anterior spine, this is articulated by a curiously complicated joint with the so-called coracoid. The cornua of the hyoid are large stout bones, and the urohyal, also a large and strong bone, which is particularly broad in *Loricaria*, connects the hyoidean with the pectoral apparatus.

On comparing this apparatus with the sternal shield of *Coccosteus*, one is tempted to compare the antero-median piece of the latter with the urohyal of the Siluroid, the antero-lateral piece with the "coracoid," and the postero-lateral piece with the so-called "radius," the more especially as the antero-lateral piece corresponds with that part of the thoracic shield of *Pterichthys* which supports the plated appendage representing the pectoral fin, in that genus.

On the other hand, it must be confessed that the closer connexion of the antero-median piece with the thoracic plates than with the hyoidean cornua, and the very backward position of the postero-lateral plates, apparently out of reach of any connexion with the fins, militate against this view; which, in addition, leaves the median rhomboidal plate unaccounted for.

The bones Mn. are, of course, as has long been determined, the rami of the mandibles of *Coccosteus*. Their singular figure is not unlike that of the corresponding bones in *Loricaria*. Finally, the long flat bones *a* (fig. 21), I have no doubt, are the chief parts of the hyoidean arch, which are also proportionately large in many Siluroids.

No one, I think, will deny that the structural coincidences here detailed are of very great weight, and that in the absence of contrary evidence they must lead us to assign a place near, if not among, the Siluroidei to *Coccosteus*. I do not know that any facts which can be adduced can be fitly considered as such directly contrary evidence, but there are several difficulties which require careful consideration.

In the first place, *Coccosteus* seems to have possessed neither basal nor lateral cranial bones,—at least, no traces of such structures have yet been discovered; so that, in all probability, this fish possessed a cartilaginous primordial cranium like that of *Accipenser;* and, indeed, a still more gristly one, for *Accipenser* has a large basal ossification. The hyomandibular suspensory apparatus must have been equally cartilaginous, and, in the vertebral column, only the superior and inferior arches were ossified. Assuredly this is very unlike what we are accustomed to see among the Teleostei, but it must be recollected that it is at least equally unlike what we find in the Ganoids, if we except those of the same epoch; and, on the other hand, there are some recent Teleostei, though there are no known Ganoidei, whose vertebral columns and skulls exhibit a correspondingly low stage of organization.*

In the second place, arises the question whether, since we know that a true Ganoid, *Amia*, completely simulates the outward form of a Clupeoid Teleostean, while retaining all the essentials of its order,—may not *Coccosteus* be also a true Ganoid which simulates the outward aspect of a Siluroid? To this question it is, perhaps impossible to give any answer, save by asking another, viz.:—Why should not a few Teleosteans have represented their order among the predominant Ganoids of the Devonian epoch, just as a few Ganoids remain among the predominant Teleosteans of the present day? When it is considered that an ichthyologist might be acquainted with every fresh-water and marine fish of Europe, Asia, Southern Africa, Southern America, the Indian Archipelago, Polynesia, and Australia, and yet know of only one Ganoid, the Sturgeon, a fish so unlike the majority of its congeners, that a naturalist might be well acquainted with almost all the fossil Ganoids, and yet not recognize a sturgeon as a member of the group,—it will not seem difficult to admit the existence of a Teleostean among the Devonian Ganoids, even though that Teleostean should in some, even important, points differ from those with which we are familiar.

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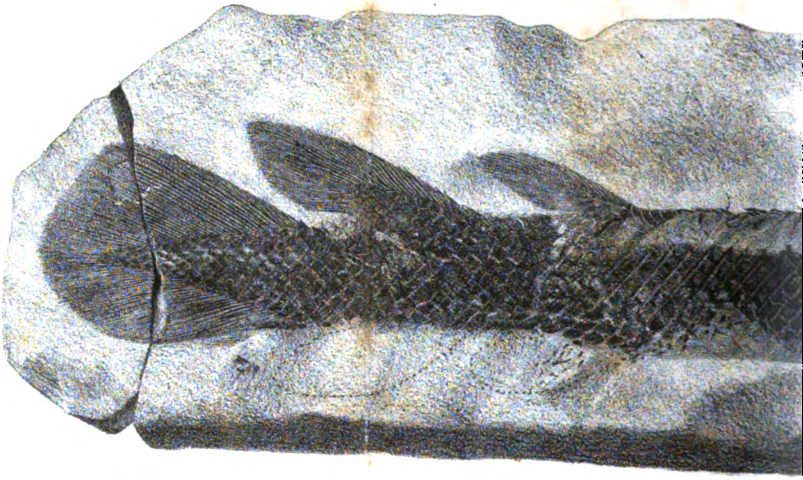
* See on this point, however, the remarks at p. 38, under (3).

Fig



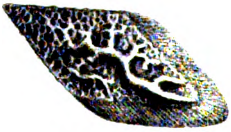


Fig. 4

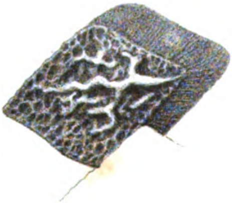


Fig. 2

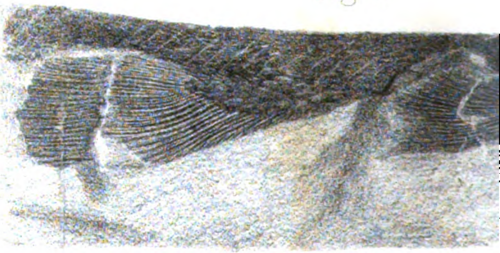
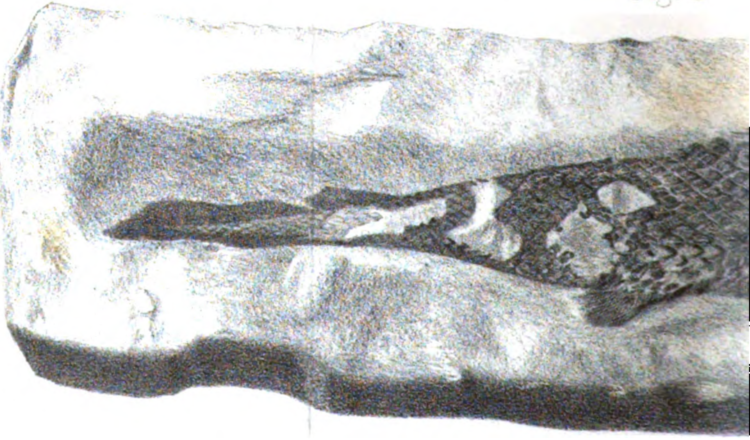


Fig. 3



kel lith

CLYPTOLŒMUS

DECADE X. PL. 1.

GLYPTOLŒMUS.

(Devonian)

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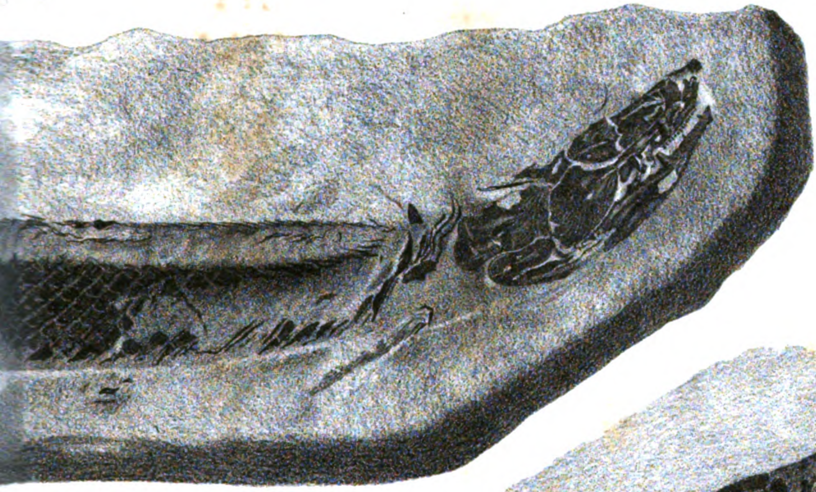


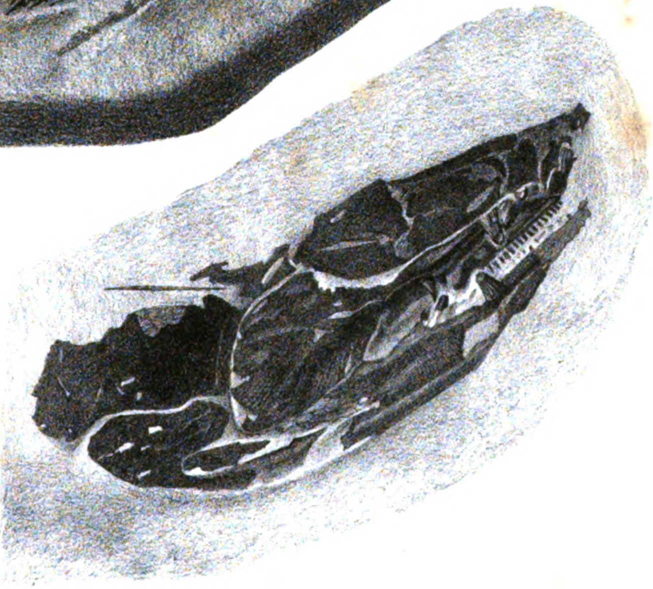
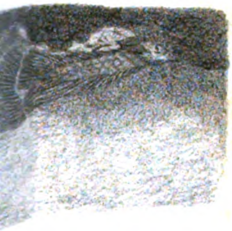
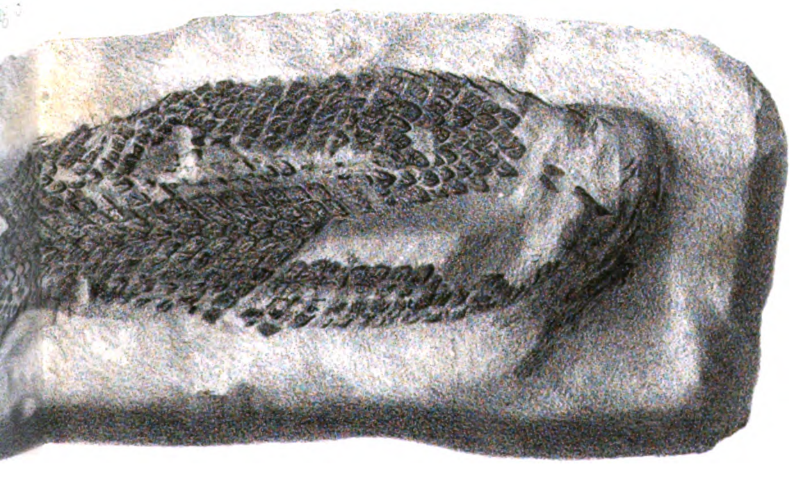


Fig. 1a





KINNAIRDI *Huxley*.

At any rate, I think the *primâ facie* case in favour of the Teleostean nature of *Coccosteus* is so strong, that it can no longer be justifiable to rank it among the Ganoids, "*sans phrase*," but that even those who will not allow it to be Teleostean must attach to it the warning adjunct of *incertæ sedis*.

No one doubts that wherever *Coccosteus* goes, *Pterichthys* must follow, and though the structure of the last-named fish is, in some respects, more difficult of interpretation than that of the former, in others it is strikingly Siluroid. For example, I know of no piscine structure that is even remotely comparable to the proximal joint of the pectoral limb of *Pterichthys*, except the corresponding articulation of the pectoral spine and fin of the Siluroids. And again the example of *Ostracion* shows that the box-like cincture of the body of *Pterichthys* is by no means foreign to the Teleostean group, though it cannot be paralleled by fishes of any other order. Whether the other "Placodermi" of Pander, such as *Asterolepis* (Ag. and Miller) really belong to the same group as *Coccosteus* and *Pterichthys*, or not, is a question which can perhaps be hardly settled at present; although, provisionally, I am much inclined to associate them together. In principle, the cranial structure of *Asterolepis*, is very similar to that of *Coccosteus*.

Having disposed of the undoubted Elasmobranchs, of the Crossopterygian Ganoids, and of the "Placodermi" of the Devonian epoch, several important and rather difficult groups remain for discussion. These are the Acanthodidæ, the genera *Cephalaspis* and *Pteraspis*, and the genus *Cheirolepis*.

The ACANTHODIDÆ have hitherto been ranked among the Ganoids, but the following considerations have often led me strongly to suspect that they might be Elasmobranchs:—

1. Their dorsal spines are similar in form and mode of implantation to those of the Elasmobranchii, except perhaps that the surface of the implanted portion is less different from the rest than in the latter order.

2. Their dermal ossicles are more like shagreen than scales.

3. As Roemer has pointed out, their lateral line runs between two rows of these ossicles, and is not formed by separate canals or grooves in successive scales as in most Ganoids and Teleosteans.

4. They seem to have had no distinctly ossified cranial bones.

5. They have no opercular apparatus, but as Sir Philip Egerton long ago pointed out to me, their branchial arches are naked.

6. The sternal part of their pectoral arch seems to have had no bony connexion with the head.

On the other hand, however, it must be considered that,—

1. The Acanthodidæ, unlike all Elasmobranchs, have great spines articulated with the pectoral arch.

2. The dermal plates of the Ganoid *Cheirolepis* are very shagreen-like, though affirmed by Pander to differ in structure from those of Acanthodidæ.

3. The cranial bones become less and less developed in the Chondrosteous Ganoids, until in *Spatularia* they are very thin squamose lamellæ; so that there is no great difficulty in the way of supposing their entire absence in a true Ganoid.

4. In the same way, the opercular apparatus, small in *Accipenser*, is still more reduced in *Spatularia.*

5. The thin, curved, toothless mandibles of *Spatularia* present, perhaps, the nearest analogue to the singular mandibular bones of *Acanthodes.*

6. As Roemer has pointed out, *Paleoniscus* has orbital plates very like those of *Acanthodes.*

7. The production of the pectoral arch into long backwardly directed processes in *Diplacanthus* and *Cheiracanthus* is the very reverse of an Elasmobranch character, seeing that the like only obtains, so far as I know, in some Siluroids.

8. *Acanthodes* is provided with two very long filaments, beset with short lateral branches, which proceed from the region of the mouth, and such oral tentacles are to be found only in Ganoids and Siluroids.

Under these circumstances the safest course probably is to regard the Acanthodidæ as a distinct suborder of Ganoids.

The genera *Cephalaspis, Pteraspis, Auchenaspis,* and *Menaspis* certainly form a family by themselves, to which the title of CEPHALASPIDÆ may be conveniently applied; but the position of this family is not readily determinable. No one can overlook the curious points of resemblance between the Siluroids, *Callichthys* and *Loricaria,* on the one hand, and *Cephalaspis,* on the other, while in other respects, they may be still better understood by the help of the Chondrostean Ganoids. Compare, for example, *Scapirhynchus* with *Cephalaspis,* or the great snout of *Pteraspis* with that of *Spatularia.* I am inclined to place the Cephalaspids provisionally among the Chondrostei, where they will form a very distinct family.

The affinities of two genera remain for discussion, the one being the well-known *Cheirolepis* of Agassiz, the other, the new genus

Tristichopterus, described by Sir Philip Egerton in the course of the following Decade.

Cheirolepis contains fishes with moderate-sized heads and markedly heterocercal tails; with a single dorsal fin, a single anal, pectorals, and ventrals. The median fins are situated forwardly, the dorsal being over the posterior part of the anal; and the ventral fins are so forward as to be almost close to the pectorals. None of these fins are lobate. The body is covered with minute rhomboidal scales, which do not overlap one another, so that the skin has quite the aspect of shagreen. Nevertheless, according to Pander, the structure of these bony scales is not so like that found in the Squalidæ as that of the scales of *Diplacanthus*.

The head is usually crushed, and its component elements displaced, but according to Professor Pander, whose account is largely borne out by the specimens I have examined, the middle of the roof of the cranium, from the posterior edge of the occiput to the anterior edge of the frontal region, is covered by two broad bony plates, which were, perhaps, divided in the middle line. Pander considers the anterior of these to be frontals, the posterior, to be parietals. At the sides of the parietals lie three narrow bones, which, perhaps, all belong to the skull, though the inner and uppermost may appertain to the shoulder girdle. The anterior edges of the other two bound the orbit posteriorly, and similarly elongated plates lie in front of the eyes, beside the frontals. The upper jaw is a large bone, rounded off posteriorly and tolerably broad behind, while anteriorly its upper edge suddenly becomes excavated to form the lower boundary of the orbit and then tapers off; it is beset with small sharp conical teeth. The gape extends very far back, and the lower jaw is a long flat bone toothed like the upper.

According to Agassiz, there were larger teeth interspersed among the smaller ones ("Recherches," p. 130; "Vieux Grès Rouge," p. 44), but all in a single row. Like Pander (l. c., p. 73), I have been unable to discover these larger teeth. The opercular apparatus and the branchiostegal rays, or their representatives, were not observed by Pander, nor have I seen indubitable evidence of their characters; but Agassiz ("Recherches," p. 132) has described and figured the branchiostegal rays of *Ch. Uragus*. "The branchiostegal rays " are very well preserved on both sides of the head; the anterior are " shorter and larger; they are well seen on the left side. The " posterior ones, which are better preserved on the right side, are " narrower and more elongated. I count at least ten of them."

According to Pander a large perforated plate surrounds the eye.

Miller, Giebel, and Pander have agreed upon the propriety of separating *Cheirolepis* from the other Acanthodidæ of Agassiz, and Pander proposed to form for it a distinct family, that of the CHEIROLEPINI. Granting, as I think every one must do, the justice of this step, the question next arises in what suborder of the Ganoids does this family arrange itself.

It certainly is not one of the Crossopterygidæ, for it has but a single, comparatively short, dorsal fin, neither pectorals nor ventrals are lobate, and there are no jugular plates; still less can *Cheirolepis* be ranked among the Amiadæ or Chondrosteidæ. On the other hand, it presents certain points of resemblance with *Palæoniscus*, and through those forms connects itself with that large body of fossil fishes which have more or less direct relations with *Lepidosteus*. Perhaps then, *Cheirolepis* ought to be regarded as the earliest known form of the great suborder of the Lepidosteidæ.

In the absence of a full knowledge of the head, of the paired fins and of the dentition, it would be hazardous to form any decided opinion as to the affinities of *Tristichopterus;* I strongly suspect, however, that it will turn out to be the type of a new family allied to the Ctenododipterini and Cœlacanthini.

The cranio-facial bones are lettered as follows in the woodcuts :—

S. O. Supra-occipital.
Fr. Frontal.
Eth. Ethmoid.
Ep. Epiotic.
Pa. Parietal.
Sq. Squamosal.
Pt. F. Post-frontal.
Pr. F. Pre-frontal.
S. T. Supra-temporal.
Pt. O. Post-orbital.
Sb. O. Sub-orbital.
Mx. Maxilla.
Pmx. Premaxilla.
H. M. Hyomandibular bone.
Qu. Os quadratum.
S. S. Supra-scapular.
Op. Operculum.
S. Op. Sub-operculum.
Ju. Jugular bones.
Sp. O. Spiracular ossicles.
St. O. Supra-temporal ossicles.

P.O. "Pre-operculum" occurs in the woodcut, fig. 2; but I am now much inclined to doubt the existence of a true pre-operculum in any Crossopterygian fish.

T. H. HUXLEY.

Jermyn Street, Nov. 1, 1861.

[NOTE.—By the great kindness of Dr. Taylor of Elgin, I have just had the opportunity of examining a beautiful, almost entire, specimen of *Glyptopomus*, with two dorsal, and exquisitely lobate pectoral, fins.—T. H. H., Nov. 18th.]

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Geological Survey of the United Kingdom.

Fig. 1.

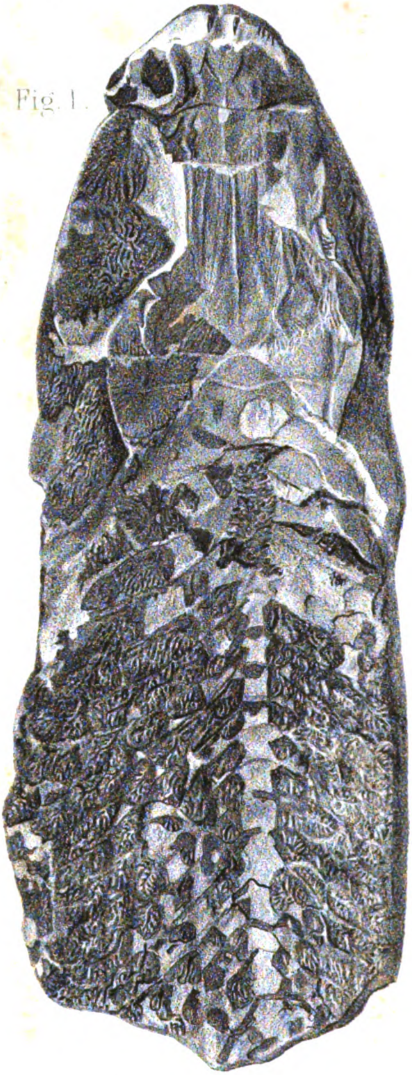


Fig. 1a

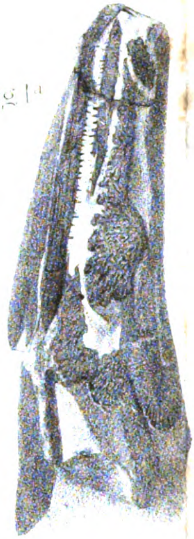


Fig. 2.

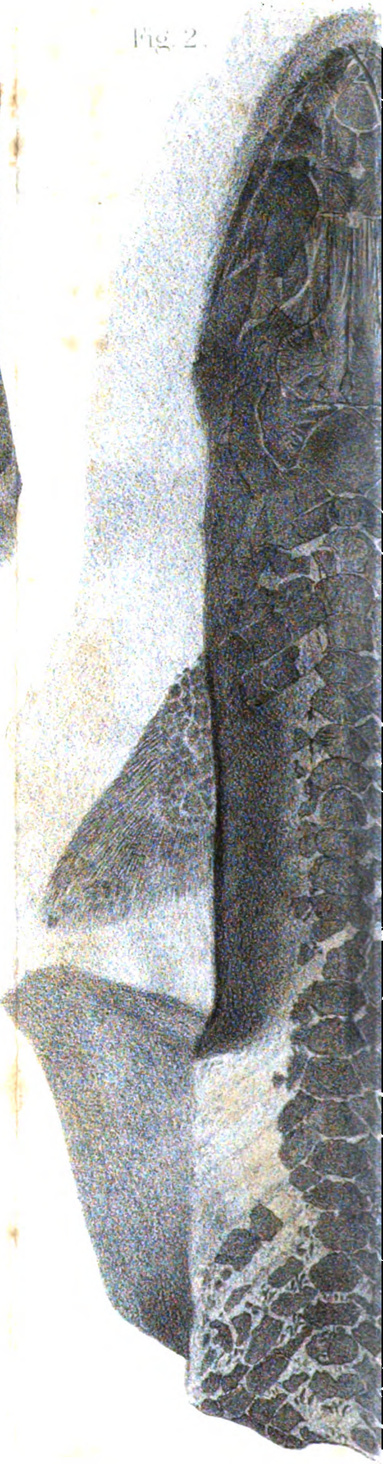
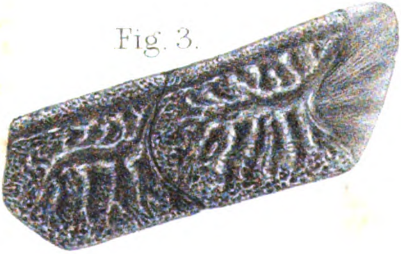


Fig. 3.



Jos Dinkel lith

GLYPTOLŒMU

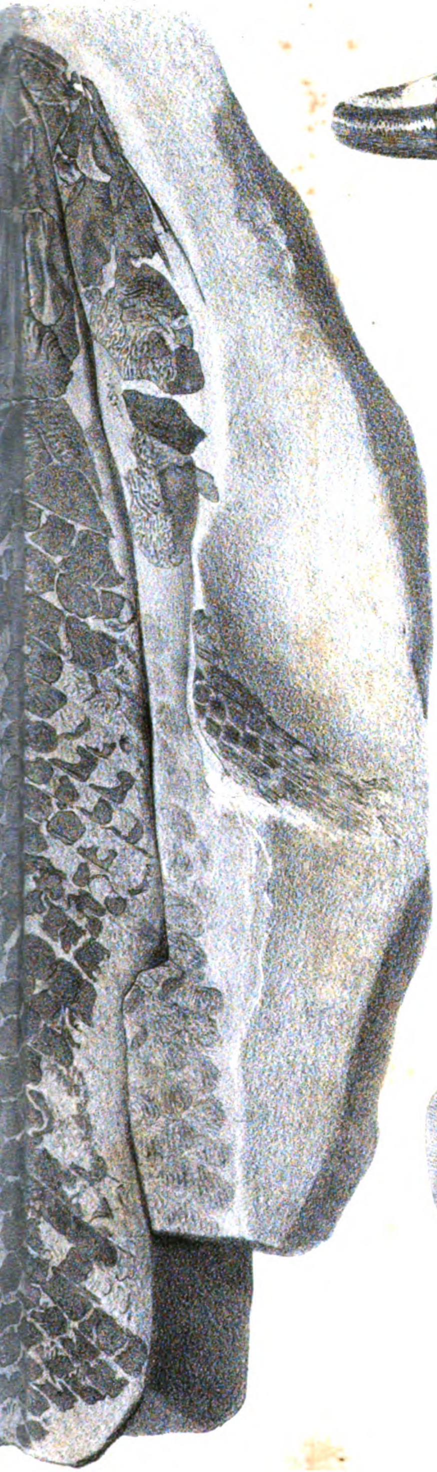


Fig 1^{b}

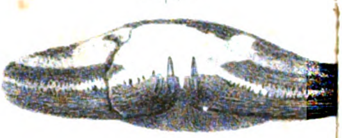


Fig 3.

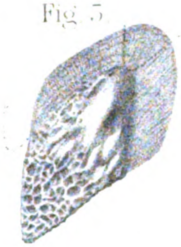
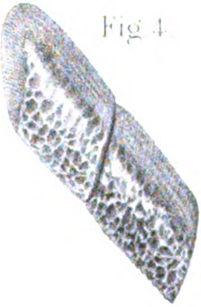


Fig 4.



EMUS KINNAIRDI *Huxley*

BRITISH FOSSILS.

DECADE X. PLATES I. AND II.

GLYPTOLÆMUS KINNAIRDI.

[Genus GLYPTOLÆMUS. HUXLEY. (Sub-kingdom Vertebrata. Class Pisces. Order Ganoidei. Suborder Crossopterygidæ. Family Glyptodipterini.) Body elongated, tapering to a point posteriorly. Cranium depressed. Dorsal fins two, distinct, situated in the posterior two-fifths of the length of the body. Ventral fins under the first dorsal, and like the pectorals lobate. The rhomboid scales and the cranial and facial bones ornamented with raised ridges. Teeth of two sizes, composed of (probably) dendrodentine. Tail diphycercal.]

Glyptolæmus Kinnairdi. SP. UNICA.

Specimens of this genus were first described, and their distinctive characters pointed out by me, in a notice inserted in Dr. Anderson's work upon "Dura Den," which was accompanied by excellent, though small, illustrative figures, drawn by Mr. Dinkel.

Since 1859, thanks to Dr. Anderson's zeal and activity, a number of additional specimens, several of great beauty and interest, have passed into the collection of the Museum of Practical Geology, so that I am now in a position to give a tolerably complete account of the structure of these ancient fishes. The singularly beautiful and accurate figures in Plates I. and II. will enable the reader, step by step, to verify for himself the most important points of my description.

The body is, as I have said, elongated, and when viewed sideways, fusiform, tapering to a point at each extremity (Plate I. fig. 1), but when viewed from above or below, though the caudal extremity is still seen to end in a point, the anterior part of the body rapidly widens (Plate I. fig. 3), and ends in a depressed, broad, and shovel-shaped head, with a semi-elliptical contour, rounded at the snout.

The length of the whole body is about four and a half times as great as the distance from the end of the snout to the posterior margin of the opercular apparatus; which distance exceeds by as much as a fourth, or a fifth, the transverse diameter of any part of the body. It somewhat exceeds, again, the perpendicular distance from the upper margin of any part of the dorsal, to the lower margin of any part of the anal fin. The greatest transverse diameter of the head is equal to the distance from the snout to the posterior margin of the parietal bones.

The specimen figured in Plate II. furnishes a very complete view of the structure of the cranium of *Glyptolæmus*, the arrangement of whose constituent elements is still further elucidated by the diagrammatic woodcuts fig. 2 (p. 2 of the "Preliminary Essay") made from enlarged and restored views of the skull and its appendages.

The cranial bones are thin and scale-like, and their surface exhibits numerous long and sinuous ridges, separated by narrow and comparatively deep grooves, which sometimes obscurely radiate from the centre of the bone.

The premaxillary bones, slender and slightly curved, uniting in a broad, but short, ascending internasal process, form the anterior boundary of the snout and limit the nostrils below, joining the equally slender maxillaries which constitute the rest of the upper boundary of the gape behind. The upper and inner edges of the ascending processes of the premaxillaries abut against the anterior margins of a flat hexagonal bone, whose posterior margins unite with the frontals, while its lateral edges are connected with the inner edges of the nasal bones. This bone is therefore obviously the ethmoid.

The frontals, which succeed the ethmoid in the middle line, are short, but comparatively narrow bones, separated by a very distinct suture, which widens in the middle of its length, so as to form a small rhomboidal fontanelle. The posterior edges of the frontals are truncated, and unite with the anterior margins of the parietals, which are almost twice as long as the frontals, and enter more largely than any other bones into the formation of the roof of the skull. The left parietal rather overlaps the right posteriorly, and each parietal suddenly widens in its posterior moiety, so that its outer edge presents a deep notch or step into which the post-frontal fits. The posterior edges of the parietals are as abruptly truncated as the anterior. They unite in the middle line with the apex of the large rhomboidal scale, or bone, which occupies the place of the supra-occipital.

The supero-lateral regions of the skull are formed in front by the large nasals; behind these by the prefrontals, which unite with the maxilla, the nasals and the frontals below, in front and above, and apparently, with the post-frontal behind. Their posterior excavated margins form the anterior boundary of the orbit.

The post-frontals, better defined posteriorly than anteriorly, appear to join the prefrontals, and then, extending backwards beyond the posterior margins of the frontals, they unite with the anterior moiety of the parietals, filling up all that notch in the outer border of these bones, which has been described. Their posterior edges are connected, internally, with the anterior margins of the projecting part of the parietal, externally with the same margins of the small quadrilateral squamosal bones.

The posterior part of the supero-lateral region is completed by two squamiform bones, which take the place of the external occipital, or epiotic, bones of other fishes, filling the interspaces left between the supraoccipital and the opercular apparatus. The inner surface of this bone, on the left side, presents a very well marked triradiate impression, one crus of which is directed transversely inwards, while the others are respectively directed forwards and backwards. A shallow groove upon the surface of the supraoccipital, which has a slight concavity forwards, connects the transverse crus of the impression on one of these bones with that on the other.

The triradiate marks are much more distinct upon the inner surface of these bones, where they form distinct ridges, than upon the outer surfaces, where they appear only as very shallow and indistinct grooves; and, except for the continuation of each transverse crus into its fellow across the supraoccipital, I should have been disposed to connect them rather with the semicircular canals of the auditory organ than with the so-called mucous grooves.

The lateral regions of the skull behind the premaxillaries are formed, in front of the orbit, by the prefrontal and maxillary, and behind the orbit, first, by the maxilla and a large postorbital bone, then by the maxilla, by the bone marked P.O., which may very likely not be a true preoperculum, and a large supratemporal bone. The latter articulates above with the postfrontal and squamosal, and fits posteriorly into the notch formed by the vertical and horizontal portions of the bone P.O.

The operculum, a large four-sided bony plate, is connected with the outer edge of the epiotic above and with the posterior edge of the ascending ramus of the bone P.O. in front. Its lower edge articulates with the upper margin of the suboperculum, which is about half as large as the operculum, and has a much more rounded posterior edge.

The palato-quadrate arcade is best exhibited in fig. 1a, Plate I., though the lines of demarcation between its constituents are not visible. Posteriorly, it is broad and expanded, furnishing the condyle to the mandibles by its outer and lower margin, while its upper and inner part probably abutted against the sphenoid. Anteriorly, it rapidly narrows, and is continued forwards as a strong bony bar. Running parallel with and outside this, is a second elongated bony ridge, which may be distinct from the foregoing, or may be only the outer part of it. At any rate, the two seem to become one in front. Here they support a very strong tooth, and there is a second large tooth situated far back upon the outer bone.

This palato-quadrate apparatus, taken altogether, very much resembles that of *Lepidosteus* in form, and in the large teeth which it bears.

The contour of the stout mandible follows that of the head, the gape extending as far back as the level of the posterior edges of the parietal bones. The rami are very stout, but appear to have consisted of only a thin osseous shell, sculptured externally in the same way as the cranial bones. The constituent elements of the mandible are not distinctly separated from one another in any specimen.

The jugular plates consist of two principal and a number of lateral scale-like bones. The former are elongated, nearly right-angled, triangles, with their perpendiculars turned towards one another, and their apices engaged in the re-entering angle of the rami, while their bases are situated midway between the articular ends of the rami and the posterior margins of the opercular apparatus. The peculiar sculpturing of these plates gave rise to the name of the genus, and is well shown in fig. 1c, Plate II. The outer edges of the principal jugular bones lie close to the inner edges of the rami of the mandible anteriorly, but posteriorly a space is left between them, which gradually widens posteriorly, and is so continued between the suboperculum and the posterior part of the principal jugular plate. This interval is filled up by the secondary jugular plates, of which, in one specimen, I count five, gradually increasing in size from before backwards. All these plates exhibit the characteristic surface ornamentation, and the last, much larger than any of the others, extends beyond the level of the posterior margin of the principal jugular plate, its curved free margin sweeping backwards and outwards, and lying between the suboperculum and the pectoral arch, while a considerable portion of the bone seems to pass under and be overlapped by the suboperculum. There is no median rhomboidal intercalary bone between the anterior and inner edges of the principal jugular bones.

The ventral part of the pectoral arch is represented, on each side, by two broad, triangular, somewhat curved, bones. The anterior one meets its fellow in the middle line, just behind the posterior edges of the principal jugular bones; but their inner margins immediately diverge, passing backwards and outwards, and being continued in the same direction as far as the posterior edge of the operculum, by the inner edge of the posterior pectoral plates. The adjacent margins of the two plates seem to be firmly united together, and their outer surfaces exhibit a marked sculpture, whose ridges are more evenly continuous than those of the cranial bones. Two large triangular scales which fit in between the supraoccipital and the epiotic appear to represent some of the upper elements of the pectoral arch.

The pectoral fins are not perfectly displayed in any specimen, but fig. 2, Plate II., shows that they were well developed, being about as long as the head, and that they were provided with numerous long and delicate fin rays which beset the edges and extremity of a stout central stem, covered with rhomboidal scales.

The ventral fins, smaller than the pectorals, were also, as figs. 2, 3, Plate I., show, distinctly lobate, their central stem being covered with rhomboidal scales and terminating in a point, at about the middle of the length of the fin.

The median fins present very distinct jointed fin-rays, and, as may be seen in fig. 1, Plate I., the scales of the body are continued on to the bases of the dorsals and anal, so as to give them, though to a far less degree, the lobate aspect of the pectorals and ventrals.

Both dorsals are pointed at their extremities, and somewhat fan-shaped, from being narrower at their bases than in their posterior moieties. The first dorsal is smaller than the second. The anal fin, opposite the second dorsal, is about as large as the latter, and has the same slightly lobate aspect.

The rhomboidal caudal fin, whose rays commence almost immediately behind those of the second dorsal and anal, is perfectly symmetrical, the axis of the tapering extremity of the body being not only free from any upward inflexion, but corresponding with the "equator" of the fin.

The scaly extremity of the body appears to stop at some distance before reaching the posterior margin of the fin, but it is difficult to make quite sure of the fact.

The scales are thin, and exhibit a sculpture of variable appearance, but always made up of raised ridges, with intervening valleys and pits over the greater part of their surface; narrow smooth facets being left along two sides to receive the overlapping edges of other scales.

A single longitudinal row of hexagonal scales occupies the middle line of the back, and a less marked row of rhombic scales runs along the ventral median line. The lateral scales, rhomboidal in form, extend from the medio-dorsal to the medio-ventral series, forming curved rows transverse to the axis of the body in general direction, but presenting a marked concavity, or re-entering angle, forwards.

With respect to the dentition of *Glyptolæmus,* I find a series of minute pointed teeth along the outer margins of both upper and lower jaws. Besides these there is a single large tooth upon each side of the symphysis of the mandible, and at least one more of the same kind, a little in front of the middle of the ramus (fig. 1b, Plate II.) In the upper jaw, the pterygopalatine apparatus is, as I have already pointed out, provided with several similar teeth.

Glyptolæmus is at present only known to occur in the Old Red Sandstone of Dura Den.

EXPLANATION OF PLATES I. AND II.

Plate I.

Fig. 1. Side view of a specimen of *Glyptolæmus Kinnairdi*, half the size of nature. This and the other figures of the plate are taken from specimens in the Museum of Practical Geology.
Fig. 1a. Head of the same, natural size.
Fig. 2. Ventral and anal fins of another specimen.
Fig. 3. Ventral view of another specimen, half the natural size. Mus. Pract. Geol.
Fig. 4. Scales magnified.

Plate II.

The figures give various views of a specimen of *Glyptolæmus Kinnairdi* in the Museum of Practical Geology, and are all, except 3, 4, and 5, of the natural size.

Fig. 1. Dorsal view of the body.
Fig. 1a. Lateral view of the head.
Fig. 1b. Front view of the head.
Fig. 1c. Ventral view of the body.
Fig. 2. Sandstone matrix into which the body fits, and which retains many of the dorsal scales and the pectoral fins.
Figs. 3, 4, and 5. Scales from different parts of the body magnified.

November 1, 1861. T. H. HUXLEY.

Geological Survey of the United Kingdom.

DECADE X. PL. 3.

PHANEROPLEURON.

(Devonian)

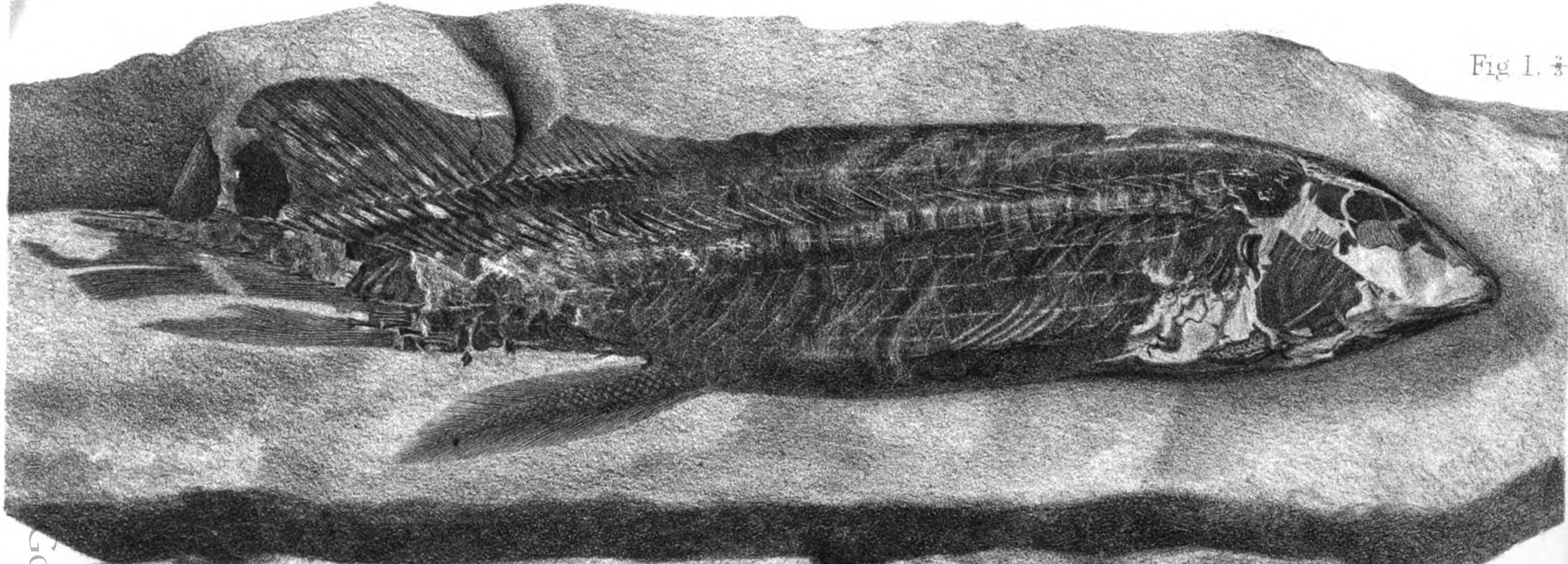


Fig 1. $\frac{2}{3}$

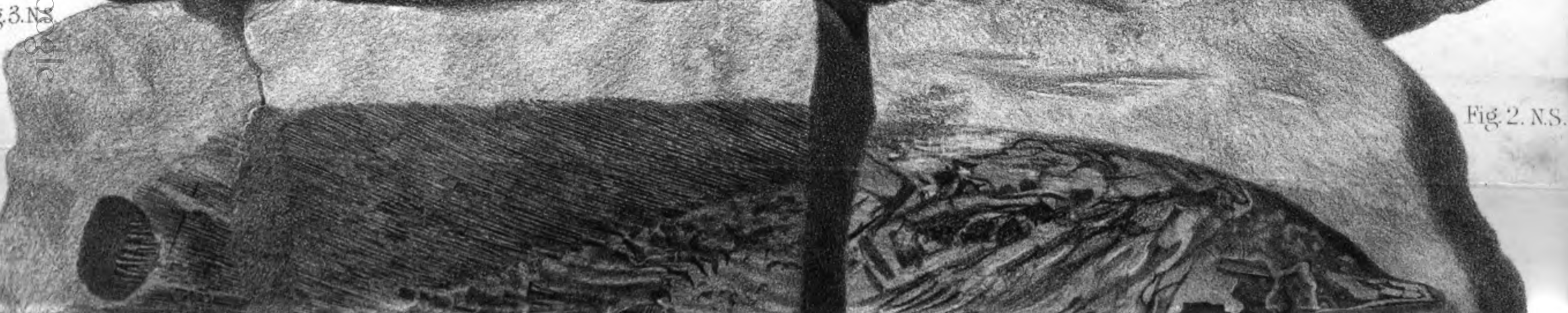


Fig. 2. N.S.

3.N.S.

Geological Survey of the United Kingdom.

DECADE X. PL. 3

PHANEROPLEURON.

(Devonian)

BRITISH FOSSILS.

DECADE X. PLATE III.

PHANEROPLEURON ANDERSONI.

[Genus PHANEROPLEURON. HUXLEY. (Sub-kingdom Vertebrata. Class Pisces. Order Ganoidei. Sub-order Crossopterygidæ. Family Phaneropleurini.) Body elongated, tapering to an acute point posteriorly, compressed from side to side. Dorsal fin single, extending for nearly the length of the posterior half of the body; the paired fins acutely lobate; the ventrals very long, apparently longer than the pectorals, and situated beneath the anterior end of the dorsal fin. Tail inæquilobate, the upper lobe being by far the smaller. Scales cycloid, very thin. Teeth numerous and conical. Neural arches, ribs, and interspinous bones well ossified.]

Phaneropleuron Andersoni. SP. UNICA.

All the specimens of this species and genus at present known have been procured from the Old Red Sandstone at Dura Den, associated with *Holoptychius,* the two genera being constantly found associated in the same slabs of sandstone. A fine series of examples is to be seen in the British Museum and the Museum of Practical Geology, the whole of which, I believe, were collected by Dr. Anderson, in whose work upon Dura Den the first description of the present species appeared. The fish had received the name of *Glypticus* from Agassiz long before, but the name was unaccompanied by any description or definition, and has been used for a genus of Echinodermata. The most complete specimen I have seen is that figured (two-thirds of the natural size) in Plate III. fig. 1, which occurs among a number of other examples of this genus and of *Holoptychius,* in a fine slab marked 26120 in the collection of the British Museum.

The length of body equals about 5½ lengths of the head. It remains of tolerably equal thickness from the pectoral region to that of the ventral fins, and then gradually tapers off to a finely pointed caudal extremity, which is, usually, slightly bent upwards. When the mouth is shut, the head also presents a triangular contour, both its upper and its under outlines rapidly shelving towards the snout.

The scales are exceedingly thin, and, apparently in consequence of containing very little bony matter, they are apt to run into one another and lose their distinctness when fossilized. But so far as the best preserved specimens enable me to judge they were large and circular, and their outer surfaces were marked by very slight and delicate, granular, radiating striæ, which may, however, be indications of internal structure and not of ornamentation (Pl. III. fig. 7). These differences from the scales of *Holoptychius* become particularly obvious when, as in the slab in the British Museum above referred to, specimens of the two genera lie side by side in the same matrix, or when, as in fig. 3, Plate III. detached scales of *Holoptychius* have become imbedded in the midst of a specimen of *Phaneropleuron.*

The cranial bones are smooth, or, at most, present irregular and scattered grooves. The cranium seems to have been much more compressed from side to side than in most Devonian fishes, but I can say little else respecting its structure, as it is much injured in all the specimens I have seen. In no specimen are the boundaries of the cranial bones defined. The operculum, however, is large. The orbit seems to have been situated far forwards, and the gape is long. Both the upper and the lower jaw are beset with a single series of sharp short conical teeth. One specimen on the slab 21620 in the British Museum, exhibits the only view of the under surface of the head I have met with, and proves that the jugular region was protected by bony plates. Whether there were more than the two principal ones, or not, however, I cannot make out with certainty.[1]

The pectoral arch is well developed, but I can say nothing as to its individual components, nor are the pectoral fins thoroughly well preserved in any specimen. Such parts of them as exist lead me to the belief that they were shorter than the ventrals, but like them acutely lobate.

No pelvic bones are discernible, but the ventral fins are beautifully displayed in two examples on the slab 26120 in the British Museum, and in another specimen marked 26117 in the same collection.

Their length exceeds the greatest vertical diameter of the body. A taper central lobe extends through the whole length of the fin, ending in a point at its fine end. It is covered throughout with cycloid scales, having the same characters as those of the body, and both edges are fringed with delicate fin-rays.

The notochord was persistent throughout the whole length of the vertebral column, while the superior and inferior arches were well developed and thoroughly ossified.

The neural spines are long, and are curved, so as to be somewhat concave forwards and upwards. In the posterior moiety of the body, elongated interspinous bones, narrow in the middle and expanded at the ends, are adapted to them. These interspinous bones increase in length from before backwards to beyond the middle of the dorsal fin, and support the fin-rays, whose bases are broad and solid, while they divide into a series of branchlets at their ends. There may be more than one fin-ray to each interspinous bone.

The dorsal fin, commencing with the posterior half of the body, gradually increases in height posteriorly, as its upper margin remains parallel with the axis of the body, while the dorsal line of the body converges towards that axis; the fin terminates posteriorly in an almost vertically truncated extremity.

The ribs attain a considerable length, even close to the head, and are continued through the whole length of the abdomen, passing gradually into the subcaudal bones. They are well ossified, and hence, in the fossil state, they stare through the thin integumentary scales of the fish so as to suggest its generic name.

The anal fin is somewhat lanceolate in shape, inclined downwards and backwards, and so long that its lower extremity is as distant from the axis of the body as the upper edge of the dorsal. It is supported by interspinous bones like those of the dorsal fin.

The inferior lobe of the caudal fin commences immediately behind the anal, and its rays appear to be supported by similar interspinous bones, at least anteriorly. It can be traced backwards to near the extreme end of the body. The superior lobe, on the other hand, seems to have been obsolete.

EXPLANATION OF PLATE III.

Fig. 1. *Phaneropleuron Andersoni*, two-thirds of the natural size. From a specimen in the British Museum, No. 26120.

Fig. 2. Head of a specimen in the Museum of Practical Geology. The upper contour of the cranium seems to be slightly distorted. Natural size.

Fig. 3. Caudal extremity of a specimen in the British Museum, exhibiting the anal fin. A scale of *Holoptychius* lies above the end of the tail.

Fig. 4. Hinder part of the body, with ribs, neural arches, interspinous bones, and impression of the caudal part of the tapering notochord. In the Museum of Practical Geology.

Fig. 5. Head and body, with the opercular apparatus and impressions of the ribs and neural arches nearly undisturbed. In the Museum of Practical Geology.

Fig. 6. Teeth magnified.

Fig. 7. A scale magnified.

T. H. HUXLEY.

Jermyn Street, Nov. 1, 1861.

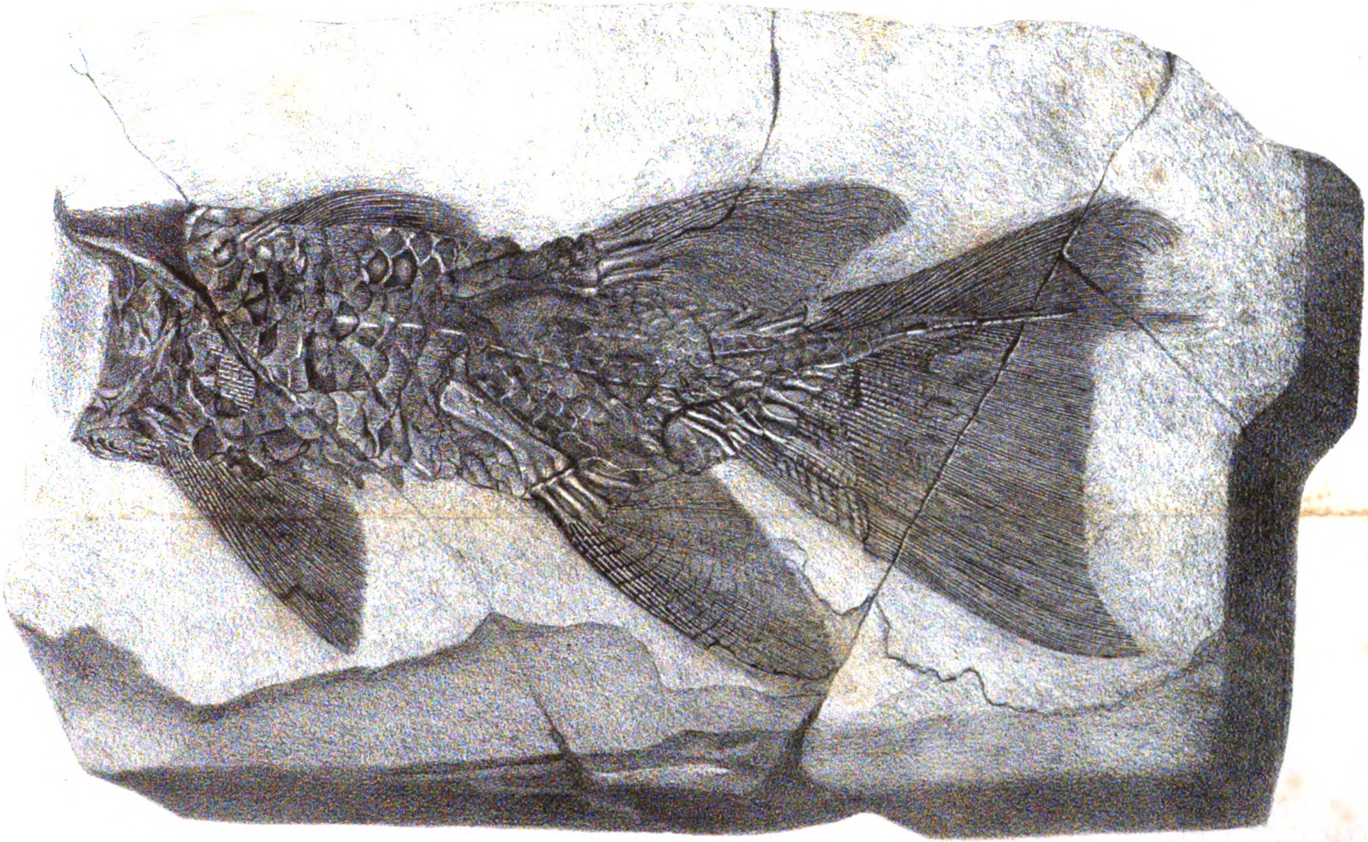
Geological Survey of the United Kingdom.

DECADE X. PL. 5.

TRISTICHOPTERUS.

(Devonian)

1



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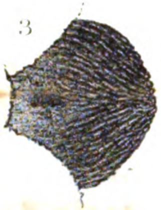

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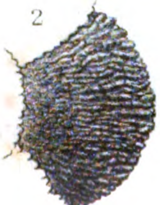
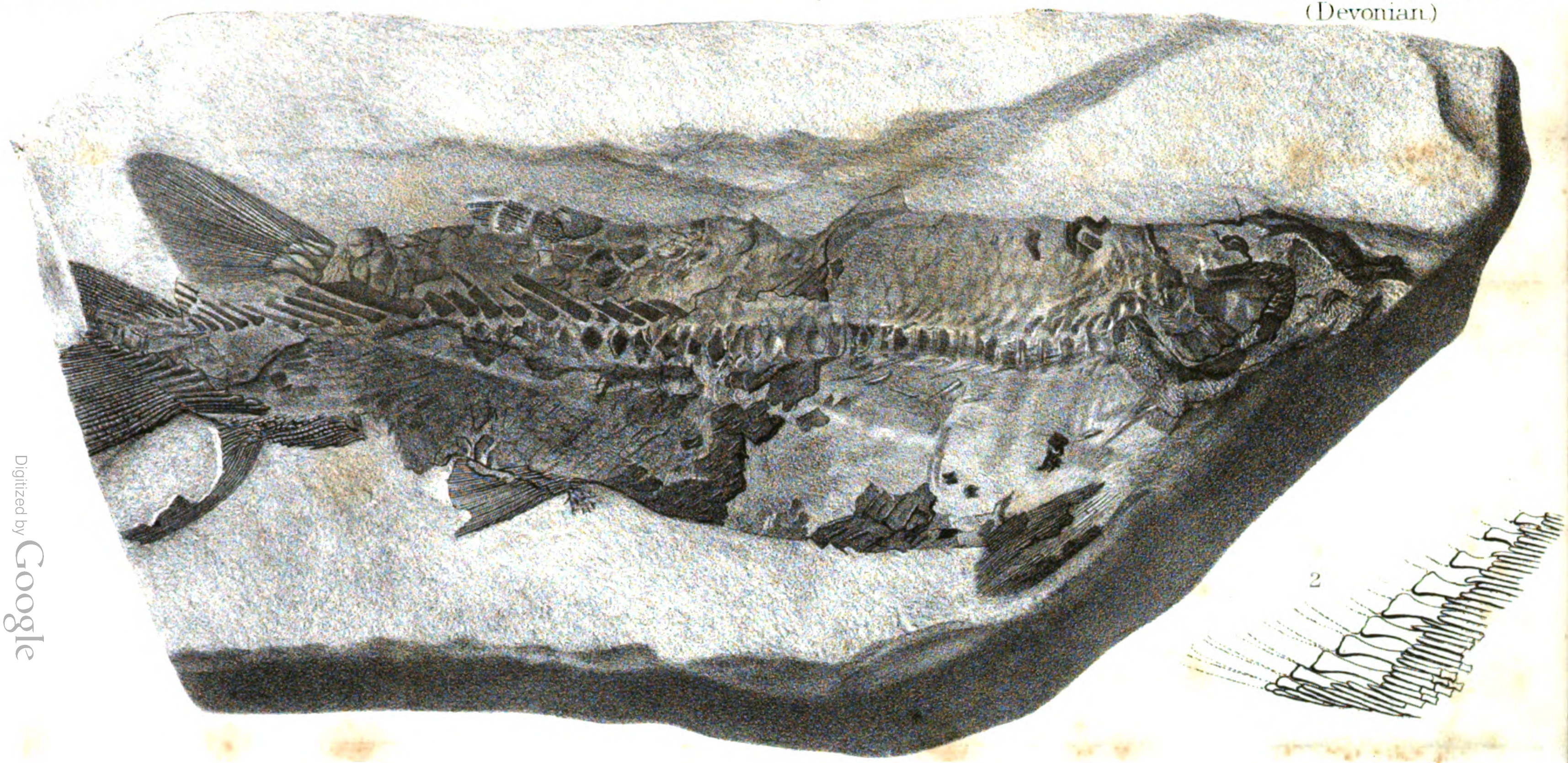


Geological Survey of the United Kingdom.

DECADE X. PL. 4.

TRISTICHOPTERUS.

(Devonian.)



TRISTICHOPTERUS ALATUS. _Egerton_.

[illegible]

Lay & Son, Lith^rs to the Queen

BRITISH FOSSILS.

DECADE X. PLATES IV. AND V.

TRISTICHOPTERUS ALATUS.

[Genus TRISTICHOPTERUS.* EGERTON. (Sub-kingdom Vertebrata. Class Pisces. Order Goniolepidoti. Family Cœlacanthi.) Body fusiform. Cranial bones sculptured. Two dorsal fins ; one anal fin ; the rays of the second dorsal and the anal fin springing from three strong interspinous bones in each. Caudal fin springing from eight or nine similar bones. Vertebral centres ossified and prolonged through the upper lobe of the caudal fin.]

Tristichopterus alatus. SP. UNICA.

This is one of the many interesting additions made to the fossil Fauna of Scotland by the zeal and intelligence of Mr. Peach. Two specimens only have been obtained, one showing the general form of the fish, with the exception of the extremities of the head and tail, the other, with its counterpart, exhibiting in perfect preservation the structural and other characters of the fins and tail. The expanse of the latter and the opposition of the second dorsal to the anal fin are characters which might lead one to refer this form to the genera *Diplopterus* or *Gyroptychius*, but a rigid examination of the specimens convinces me that it formed a member of the Cœlacanthoid family, although presenting some important discrepancies from the other genera of that family. The points of resemblance are seen in the number and position of the fins, the curvilinear outline of the scales, and the prolongation of the central portion of the tail. The differences consist in the structural details of the fins and the ossification of the vertebral centres ; but in these respects the deviation from the *Sauroidei-dipterini* is quite as great as from the *Cœlacanthi.*

Description.—The more perfect of the two specimens measures seven and a half inches in length ; if to this we add two and a quarter inches, the dimensions of the tail supplied by the second specimen, and three-quarters of an inch for the absent portion of the head, the entire length of the fish will be ten and a half inches. The depth at the greatest diameter is two inches. The body is irregularly fusiform, the dorsal line being less curved than the ventral outline, and the anterior half of the body more obtuse than the caudal portion. The bones of the head (with the exception of a small fragment of the operculum) are wanting, but the impressions distinctly left upon the matrix show that they were sculptured in rather a bold pattern, not unlike the ornament on the cranial bones of some of the *Holoptychii*, and consequently differing in this respect from the corresponding parts in *Dipterus.* The pectoral fins are very indistinctly seen. They appear to have had a short obtuse lobe forming the base, and extending therefrom a set of numerous fin-rays more elongated than those forming the pectoral fin in *Dipterus.* The small anterior dorsal fin is situated at the commencement of the last third of the body, and is opposed to the ventral fins. The latter are broad and composed of numerous rays expanding from a short lobate base. Both these and the pectoral fins differ from the corresponding organs in *Dipterus* in having more numerous and longer rays.

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* From τρεῖς tres, στίχη series, πτερὸν ala.

The structure of the other fins is very singular and requires a more detailed description. The second dorsal fin is placed immediately opposite the anal fin, and resembles it so closely that one description will serve for both. In each of these fins the component rays spring from three interspinous bones, and these are attached to a single broad spinous apophysis. The latter bone is probably a composite one, formed by the union of three or more spines. The interspinous osselets have cylindrical shafts expanded at each extremity, the one for attachment to the vertebral spine, the other for affording a base for the insertion of the fin-rays. In the anal fin the anterior bone of the triplet is shorter than the others and than the corresponding bone in the dorsal fin. The fin-rays springing from the first bone are the strongest. The anterior ones are the shortest and they lengthen in succession until the maximum extent of the fin is attained. They are single at first, but bifurcate in the distal part of the fin. The transverse joints are numerous. The group abutting upon the first interspinous bone contains about six rays. The second bone carries about eight rays, more slender than the former and more frequently subdivided. The anterior ray of this group is the longest, the subsequent ones decreasing in length in succession. The third bone gives attachment to at least a dozen rays, finely fimbriated, and forming the posterior fan-like portion of the fin. The integuments extended over the interspinous bones as far as the commencement of the true fin-rays, thus forming the lobate base so characteristic of the fins in all the Cœlacanthoid fishes. The upper lobe of the tail contains numerous rays, the anterior ones being short and fulcral, forming a marginal fringe along the upper edge of the fin. A few of the upper fin-rays are given off from a set of short neurapophyses, but the terminal rays seem to abut upon the vertebral axis. This is prolonged through and beyond the caudal fin, and is furnished at its extremity with a few fine rays forming a kind of supplemental fin projecting beyond the terminal margin of the normal caudal fin. This peculiar form of tail is common to many of the Cœlacanthoid genera, and is most fully developed in the genus *Cœlacanthus* from the Permian and Carboniferous beds. It differs from the "diphycercal tail" of Prof. M'Coy, in which the upper and lower rays of the true caudal fin form the terminal point. This form is characteristic of the genera *Diplopterus* and *Gyroptychius* belonging to the *Sauroidei-dipterini*. The lower lobe of the tail is constructed upon a plan similar to that above described as occurring in the second dorsal and anal fins, but the interapophyseal osselets are more numerous. They are eight or ten in number, and each carries four or five rays. These rays are stouter than those of the upper lobe and are more frequently jointed and subdivided; the rays, above the upper interapophysis, forming the central area of the tail, impinge upon the lower periphery of the vertebral column, and decrease successively in length so as to form a vertical termination to this lobe of the tail. The condition of the vertebral axis in this fish forms a remarkable exception to the general law hitherto applicable to the greater part (if not to all) the fishes of the Old Red Sandstone, and to all the *Cœlacanthi* hitherto described. If we except the genus *Dipterus* (some specimens of which show a tendency to ossification in the caudal region) all the Devonian genera have been considered *Notochordal* fishes, that is to say, the *chorda dorsalis* has persisted in its embryonic condition without any trace of segmentation. In the present subject, however, the whole of the vertebral axis has left its impression distinctly on the matrix in one specimen, and in the other the vertebræ of the caudal region are preserved entire. There can be no doubt entertained therefore that in this genus the ossification and segmentation of the column was complete, in which respects it stands alone among the contemporaneous fishes. The scales more nearly resemble those of *Dipterus* than any other, but the surface ornament is differently arranged. The enlarged representations of two scales, one from the flank, the other from the lateral line, most carefully drawn by the skilful pencil of Mr. Dinkel, show the characters more clearly than any description can do. The posterior margins of the scales are all curvilinear, differing in this respect from *Gyroptychius*.*

Affinities.—In assigning this new form to the Cœlacanthoid family, I have been mainly influenced by its resemblance in many respects to *Dipterus*. The latter genus was arranged by Professor Agassiz with the *Sauroidei-dipterini*, but I have long ago seen sufficient reasons for considering it a Cœlacanth, approximating more nearly to *Glyptolepis* and *Holoptychius* than to any other genera. Professor Pander, however, in his work on Fossil Ichthyology, a publication remarkable alike for the labour it evinces and the extraordinary beauty of the illustrations, has issued a monograph on the genus *Dipterus*, in which he disagrees with this arrangement (first published by Professor M'Coy), and seeks to establish a new family for its reception, which he designates "*Ctenodipterini*." Hugh Miller, so long ago as the year 1848,† made known the curious discovery that the fossil crania named by Professor Agassiz "*Polyphractus*," belonged to the genus *Dipterus*, and furthermore, that the palatal teeth called "*Ctenodus*" by the same author, constituted the dental apparatus of the same genus. Professor Pander seems to have arrived at the same conclusion in 1858, not being aware of the previous discoveries of Hugh Miller, whose claim to priority, however, he acknowledges in a postcript. At the same time, Hugh Miller exposed the fallacy of assigning two anal fins to *Dipterus*, proving the so-called anterior anal fin to be one of a pair of ventrals. Professor Pander entertains the same opinion, but does not allude to Hugh Miller's correction, nor does Professor M'Coy seem to have been aware of it, as he describes the genus as having two anals. The genera *Osteolepis*, *Diplopterus*, and *Glyptolepis* are also rightly deprived of the anterior anal fin in Professor Pander's publication. The term *Ctenodipterini* is intended to express the association of the dental apparatus called *Ctenodus* with the genus *Dipterus*, but it is an objectionable term, inasmuch as it suggests the idea of a Dipterian fish with Ctenoid scales. If the family is proved to be well founded, the title *Ctenodo-dipterini* would be preferable. The genera *Ceratodus* of Agassiz, and *Conchodus* and *Chirodus* of M'Coy are referred by Pander to this family. The absence of all evidence as to the dental apparatus of *Tristichopterus* is much to be regretted. On other points the affinities between this genus and *Dipterus* are so striking that they cannot be classified in separate families.

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* Professor M'Coy figures a scale (Plate 2 c. Fig. 2 a. British Palæozoic Fossils), which he describes as a scale from the back of *Gyroptychius angustus*. It very much resembles a scale of *Tristichopterus*.

† *Witness* Newspaper, December 23, 1848.

Locality.—At the meeting of the British Association at Aberdeen in 1858, Mr. Peach read a short notice of several new forms of fossil fishes discovered by himself in the north of Scotland. The subject of the present Memoir is thus alluded to: "The great " interest attaching to the next arises from its having a short " vertebral column running from head to tail, and also strong in" ternal supports to the fin-rays. Whether these and the vertebral " column are of bone is still an open question. The scales are " large and coarse; it is about ten inches in length; and came from " the red and blistered sandstones near John o'Groat's House." The second specimen, contributing materially to the knowledge of the genus, is not mentioned by Mr. Peach. Both these specimens now form part of the collection in the Museum of Practical Geology.

EXPLANATION OF PLATES IV. AND V.

Plate IV.

Fig. 1. *Tristichopterus alatus*, size of nature.
Fig. 2. Structure of the tail, magnified.

Plate V.

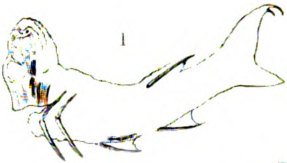
Fig. 1. *Tristichopterus alatus*, size of nature.
Fig. 2. Scale of the flank, magnified.
Fig. 3. Scale from the lateral line, magnified.

P. DE M. GREY EGERTON.

Oulton Park, Nov. 15, 1860.

ACANTHODES.
(Devonian)

1



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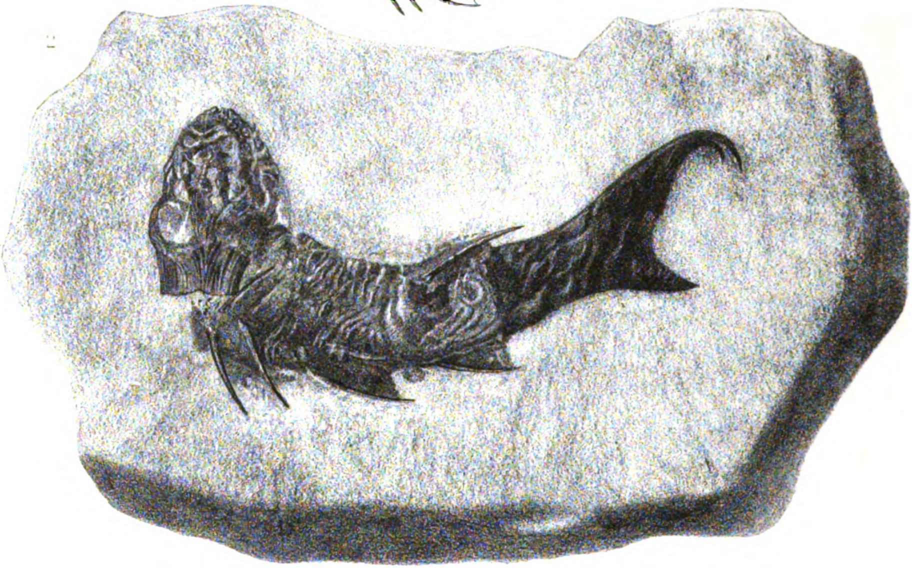

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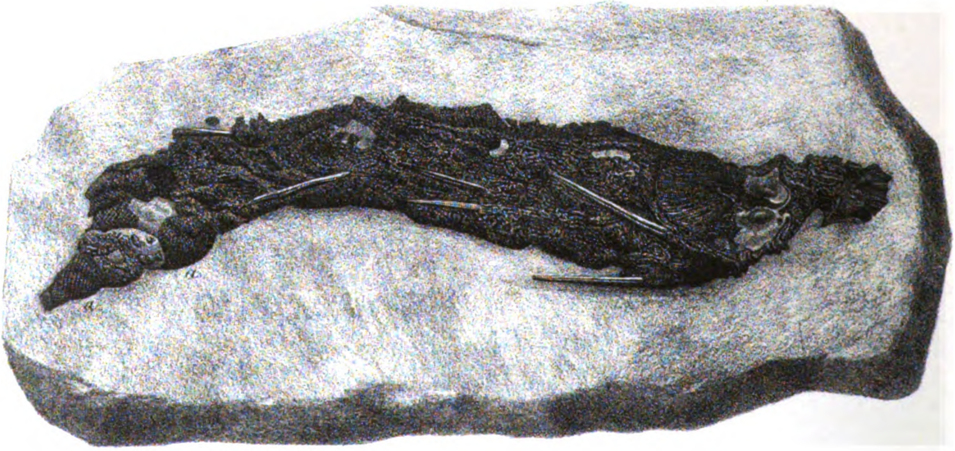

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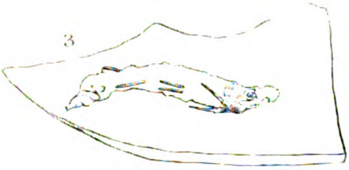

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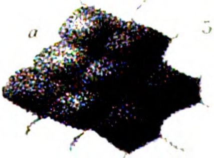

coriaceus

ACANTHODES PEACHI _ *Egerton*

ACANTHODES CORIACEUS _ *Egerton*

BRITISH FOSSILS.

DECADE X. PLATE VI. Figs. 1 and 2.

ACANTHODES PEACHI.

[Genus ACANTHODES. AGASSIZ. (Sub-kingdom Vertebrata. Class Pisces. Order Goniolepidoti. Family Acanthodei.) Body fusiform. Mouth large, opening upwards. Orbits encircled by four bony plates. Branchiæ exposed. Fins membranous, supported by strong spines. One dorsal spine near the tail; one anal below and slightly in advance of the dorsal; pectoral spines strong; ventral spines small. Scales minute.]

The genus *Acanthodes* forms the subject of the first article in Professor Agassiz's volume on the Ganoid fishes. At that time only one species was known, *Acanthodes Bronni*, from the Coal-measures of Saarbrüch. Before the completion of the work, two others had been discovered, *Acanthodes sulcatus*, from the Coal-measures at Newhaven, and *Acanthodes pusillus* from the Old Red Sandstone near Gordon Castle. In the description of the latter species, in his later publication on the fishes of the Old Red Sandstone, Professor Agassiz supplements the characters of the genus given in the former work, with all the information derived from these subsequent discoveries. It was reserved, however, for Ferdinand von Römer, of Breslau, to complete the anatomical details of this singular fish, by the examination of hundreds of specimens (as he himself recounts) of a new species, *Acanthodes gracilis* (*Holacanthodes* of Beyrich), discovered in the Permian strata of Klein-Neundorf, near Löwenberg.* Since the publication of this memoir (to which I must refer the reader for the many curious structural details therein described), the Old Red Sandstone of Scotland has contributed three additional species to this genus. These will be considered in this and the following chapter. Two of these novelties were discovered by Mr. Peach, and in recognition of the great services he has rendered to Palæontology I propose to designate the subject of this article by his name.

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* Ueber Fisch-und Pflanzen-führende Mergelschiefer des Rothliegenden bei Klein-Neundorf unweit Löwenberg, und im Besonderen über *Acanthodes gracilis* den am häufigsten in denselben vorkommenden Fisch.—Von Herrn Ferd. Roemer in Breslau, 1857.

Description.—Although somewhat longer than the *Acanthodes pusillus* from Tynet Burn, this is, nevertheless, one of the smaller species of the genus. The length of the only specimen found in tolerable preservation is about $2\frac{1}{10}$ inches. The depth of the the body is four-tenths, and caudal pedicle two-tenths of an inch. It differs remarkably from *Acanthodes pusillus* in these relative dimensions, being a thicker fish and less elegant in its proportions. The latter species is usually found doubled up upon itself, as if it had died a violent death. The Caithness species is also recurved, as if it had met with a similar fate; but, owing to the greater rigidity of the body, the distortion has been less excessive. The head seems to be large in proportion to the body, but this appearance may be due to the mutilated condition of this portion of the specimen. Owing to a forcible disruption of the integuments at the junction of the head and thorax, the former has been thrown up and crushed vertically, in consequence of which its natural proportions are disfigured by the lateral projection of the component bones. The pectoral fins remain in their proper position. They are supported by two strong spines, slightly recurved. The portions of the thoracic arch, to which these spines are attached, are seen sloping upwards from the articulation. They probably represent the coracoid bones. They are of slighter proportions than the corresponding bones in the genera *Cheiracanthus* and *Diplacanthus*. The ventral fins are situated about midway between the pectoral and anal fins. They are furnished with two spines, more slender than the other fin spines, but longer in proportion than in any other species of this genus. The dorsal fin is placed in a more forward position than the corresponding organ in the allied species. Instead of being slightly more remote than the anal fin, it is immediately above it. The spine which carries the fin is the strongest of the set. It is more curved than the dorsal spine of the other species of contemporaneous origin. The anal spine is also strong and curved. All the fin spines are ornamented with three or four longitudinal grooves. The tail is very broad for the size of the fish. The upper lobe projects beyond the lower lobe to a considerable extent, but does not taper off so gradually as in other species. The appearance of a bifurcation at the extremity is due to a separation of the integuments, either from pressure or decomposition. The scales are very minute, at the same time they appear to have been coarser than the scales of *Acanthodes pusillus*.

Locality.—This specimen was discovered by Mr. Peach about four years ago in a quarry of the Old Red Schist belonging to the Earl of Caithness, near Barragill. It is now in the Museum of Practical Geology in Jermyn Street.

PLATE VI. Figs. 3, 4, 5.

ACANTHODES CORIACEUS.

This singular little fish is another of the novelties produced at the Aberdeen meeting by Mr. Peach. It is not without hesitation that I refer it to the genus *Acanthodes*, but as the only alternative would be to establish a new generic definition, the preferable course, it appears to me, is the one thus adopted, since it is better to defer the introduction of a new title until good and sufficient materials substantiate its necessity, than to enter a new generic name on the list, already overcrowded, which may hereafter be found to be unnecessary.

Description.—The unique specimen of this fish discovered by Mr. Peach scarcely exceeds 1 inch in length. It reposes on the left side, having the ventral surface slightly upturned so as to display all the fins. It will be seen on referring to the enlarged representation most accurately delineated by the practiced and skilful hand of Mr. Dinkel, that the arrangement of the several fins is in close correspondence with the fin formula of the genus to which I have referred it. There are two pectoral fins, two ventral fins, one dorsal, and one anal fin, all armed with spines. The pectoral spines are the longest, and the ventral spines the shortest of the series. The dorsal and anal spines are intermediate in size, and both of the same length. The body of the fish is more slender and the fins more distant from each other than the corresponding parts of *Acanthodes Peachi.* The dorsal fin is also more remotely placed than in that species. These discrepancies forbid the idea I once entertained that it might possibly be the fry of that species. The most striking feature of this fish is the integumental covering. It has all the appearance of a thick corrugated skin, with here and there a trace of very minute scales. These are most evident near the caudal extremity, and a group of them from this spot has been carefully delineated by Mr. Dinkel. If the surface here seen be the true exterior layer, and not the result of decomposition, it would appear to be more granular than the coating of other Acanthodean scales.

Locality.—Mr. Peach found this specimen near Thurso, and described it as a smaller species than the preceding one "with strong and long spines, and as if clothed with a thick skin." The specimens figured are in the collection of the Museum of Practical Geology.

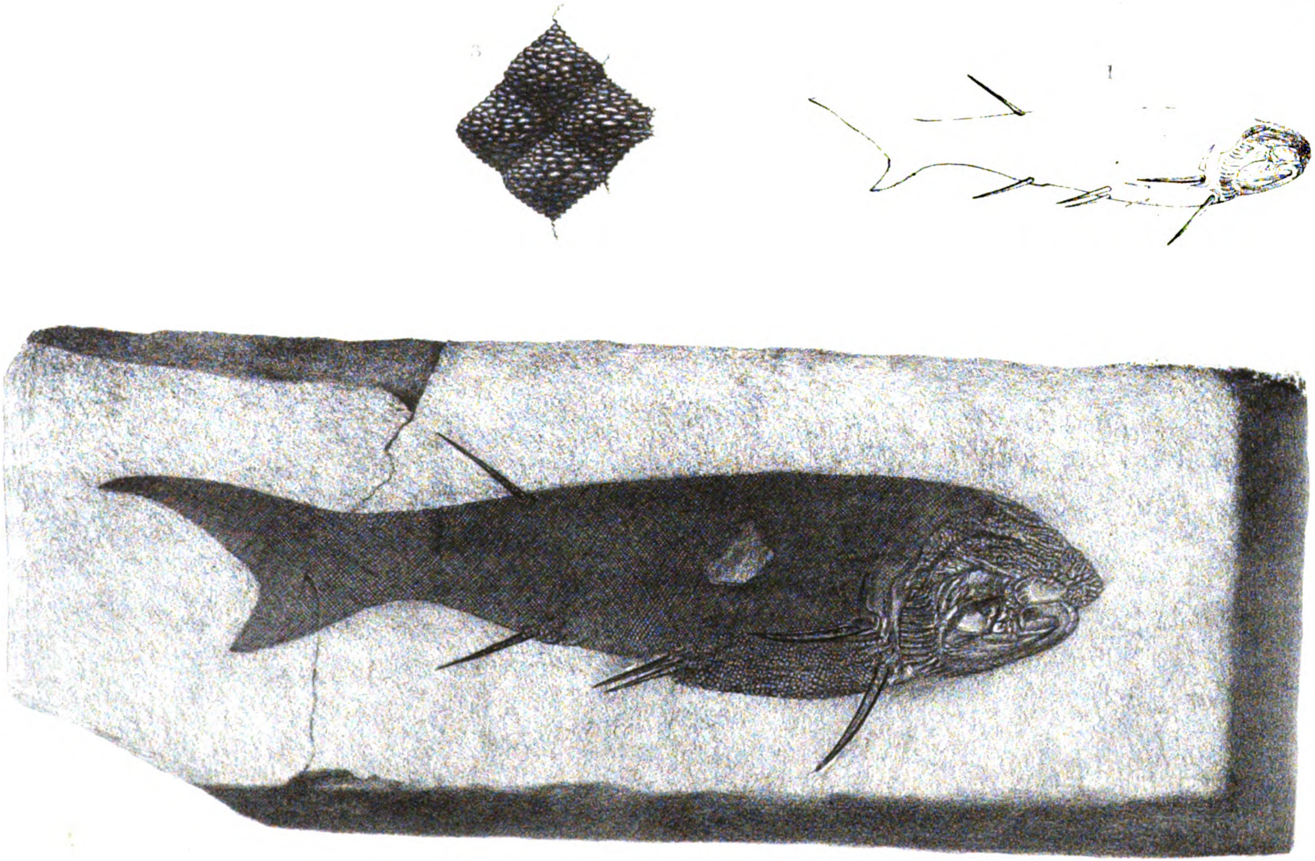
Explanation of Plate VI.

Fig. 1. *Acanthodes Peachi*, size of nature.
Fig. 2. „ „ enlarged once.
Fig. 3. *Acanthodes coriaceus*, size of nature.
Fig. 4. „ „ enlarged twice.
Fig. 5. Scales of ditto, greatly magnified.

P. de M. Grey Egerton.

Oulton Park, Nov. 27, 1860.

DECADE X. PL.
ACANTHODES.
(Devonian.)



ACANTHODES MITCHELLI *Egerton*

BRITISH FOSSILS.

DECADE X. PLATE VII.

ACANTHODES MITCHELLI.

[Genus ACANTHODES. AGASSIZ. (Sub-kingdom Vertebrata. Class Pisces. Order Goniolepidoti. Family Acanthodei.) Body fusiform. Mouth large, opening upwards. Orbits encircled by four bony plates. Branchiæ exposed. Fins membranous, supported by strong spines. One dorsal spine near the tail; one anal below and slightly in advance of the dorsal; pectoral spines strong; ventral spines small. Scales minute.]

SYNONYM. *Acanthodes antiquus*, EGERTON. Report of Brit. Assoc., 1859, p. 116.

At the meeting of the British Association for the Advancement of Science, held at Aberdeen in the month of September 1859, the Rev. Hugh Mitchell, of Craig near Montrose, communicated to the Geological Section a notice of the occurrence of fossil fishes in the Old Red Sandstone formation in Forfarshire. A cursory examination of the specimens exhibited in illustration of the memoir, satisfied me that the species discovered at Farnell were new to science, and I consequently named the subject of the present article *Acanthodes antiquus*. I subsequently saw two other new species of the same genus from the Old Red Sandstone of Scotland, and, therefore, cancelled the incorrect and objectionable specific affix, and substituted the name of the discoverer of this pretty and well characterized species.

Description.—The specimens I have examined of this pretty little fish vary from two inches to two and three-quarters of an inch in length. The one I have selected in illustration of this Memoir measures two inches and a half. The deepest part of the body (Pl. VII., fig. 2.) is at a point midway between the pectoral and the ventral fins. It here measures half an inch. The head measures about one-fifth of the entire length. The cranial bones are gracefully sculptured with deep sinuous lines. The orbit occupies an advanced position, and is embraced by a set of the singular orbital plates first noticed and described by Ferd. Römer as characteristic of the genus *Acanthodes.* The branchial apparatus also corresponds with that ot the other members of the genus. The outline of the body is remarkably graceful. It is fusiform anteriorly, and tapers gradually posteriorly to the base of the caudal fin. The latter organ is highly heterocercal, although the upper member is not so much extended as the corresponding part in the genus *Climatius.* All the other fins are supported by stiff spines. The pectoral spines are long and curved, the other fin spines are more slender and straight. The ventral fins are situated nearer to the anal than to the pectoral fins, and the dorsal spine is slightly nearer the tail than the anal fin. The species differs from its congeners in having the cranial bones more deeply sculptured, and in the form and position of the fin spines. It is most nearly allied to *Acanthodes Peachi,* but it differs from this species in the form of the body, in having the pectoral spines more curved, and the other spines straight, and in the more remote position of the dorsal fin.

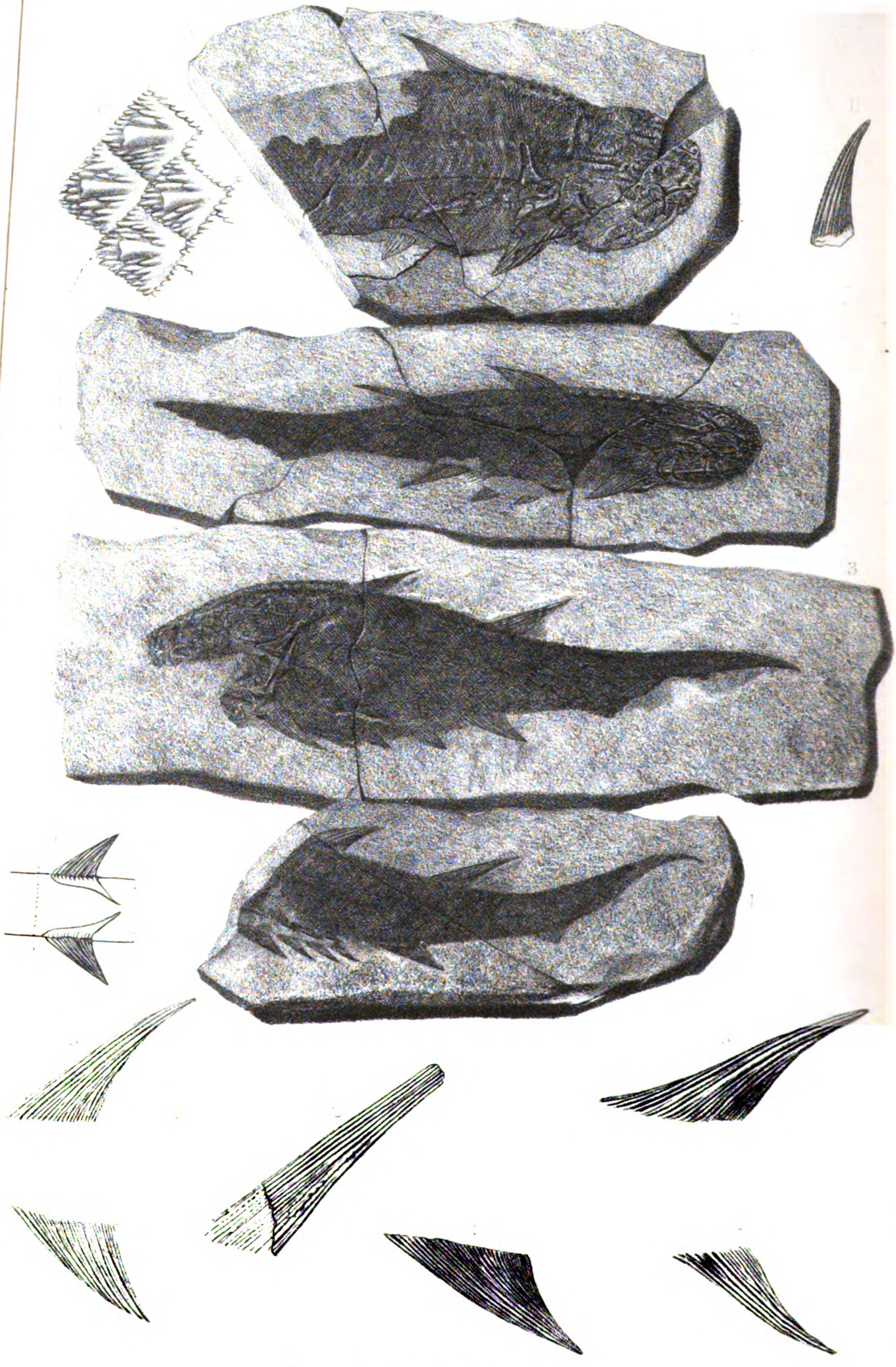
Locality.—The deposit which has yielded this and the following interesting additions to the Fauna of the Old Red Sandstone of Scotland, is situated on the south-east bank of the Pow burn about half a mile south-west of the Farnell station on the Scottish North-Eastern Railway. It is described by Mr. Powrie as consisting mostly of fine grayish argillaceous shales, the lower beds splitting into fine laminæ nearly as thin as writing paper, and, when first opened, of a delicate cream colour. In a subsequent part of the paper the author says, "no painting could equal the beautiful appearance " some of the smaller fishes exhibit when the little slab in which " they have been entombed is first opened up, and still damp." The Rev. Henry Brewster of Farnell was the first to discover the fossiliferous character of these shales, but the Rev. Hugh Mitchell of Craig first ascertained the association of fishes with the organisms previously discovered, and called attention to the subject in a paper he communicated to the Geological Section of the British Association at the Aberdeen meeting in 1859. Through the liberality of Lord Southesk, to whom the quarry belongs, every facility has been afforded for exploring its contents, and the zealous labours of Mr. Powrie and the Rev. Henry Brewster have added considerably to the stock of materials collected by the Rev. Hugh Mitchell. I am indebted to all these gentlemen for the generous confidence with which they have entrusted to me the fragile treasures of their several museums, although well aware of the risk of injury to which they must be submitted in travelling from one extremity of the kingdom to the other.

Explanation of Plate VII.

Fig. 1. Outline of *Acanthodes Mitchelli*, size of nature.
Fig. 2. The same drawn in detail, twice the size of nature.
Fig. 3. Scales highly magnified.

P. de M. Grey Egerton.

Oulton Park, December 1860.



[illegible] SCUTIGER [illegible]

[illegible] TICULAT [illegible]

BRITISH FOSSILS.

DECADE X. PLATE VIII.

CLIMATIUS SCUTIGER.

[CLIMATIUS. AGASSIZ. (Sub-kingdom Vertebrata. Class Pisces. Order Goniolepidoti. Family Acanthodei.) Body more or less fusiform. Tail heterocercal, attenuated. Fins membranous, supported by strong conical spines, striated longitudinally. Two dorsal spines; one anal spine; two pectoral spines; and two ventral spines. Three dermal spines on either side, between the pectoral and ventral fins. Dorsal ridge invested with large scutes.]

SYNONYMS.—*Brachyacanthus scutiger.* EGERTON, Report of Brit. Assoc. 1859, p. 116. *Ictinocephalus granulatus.* PAGE, Report of Brit. Assoc. 1858, p. 105.

The collection of specimens from the Farnell deposit, exhibited by the Rev. Hugh Mitchell at Aberdeen in 1859, contained, in addition to the *Acanthodes,* described in the preceding Memoir, several fragments of a small fish having considerable resemblance to the genus *Diplacanthus.* A closer examination of the best preserved specimen revealed, however, so many important points of difference that I was induced to assign to it a new generic title. The singularly short and massive character of the spines supporting the fins suggested the name *Brachyacanthus.* I have since found in Professor Agassiz's "Poissons Fossiles du Vieux Grès Rouge," the representation of a spine found at Balruddery, and described as a Placoid Ichthyodorulite, under the name of *Climatius reticulatus,* which I have no hesitation in identifying as belonging to a species of the Acanthodean genus under notice, although specifically distinct from the Farnell specimens. The name *Brachyacanthus* must consequently give way to the prior title *Climatius.*

Description.—The interest excited by the exhibition of these beautiful ichthyolites at the Aberdeen meeting gave such an impetus to the exertions of the explorers of the Farnell deposits that abundant materials shortly repaid their labours, not only for the full elucidation of the genus under notice, but for completing the knowledge of several other associated forms. Through the kindness of Mr. Powrie, the Rev. Hugh Mitchell, and the Rev. Henry Brewster, I have been enabled to examine the most perfect specimens hitherto discovered, and from these materials the following description of *Climatus scutiger* is derived. The specimens comprise two forms, the one of more slender proportions than the other. In the absence of more important differential features, it would be impolitic to attach specific value to a discrepancy of this kind; it may be due to casual or local influences, or be a sexual character. It suffices for the present to notice the fact, leaving the question of specific value to be settled by future investigation. The specimens range from one inch and a half to two inches in length, from the snout to the base of the tail. The latter organ is rarely preserved entire, in consequence of its extreme tenuity and delicate structure, and the fragile texture of the shale in which the specimens are imbedded; but I am informed by Mr. Powrie, who had the advantage of seeing the specimens when first uncovered, that the upper lobe of the tail measures about one-third of the total length of the fish. This measurement would give about three inches as the extreme length of a full grown individual. The form and proportions of the head closely resemble those of the head of *Acanthodes*. As in that genus, the surface of the cranial bones is richly chased, but the sculpturing, instead of being continuous in vermicular gyrations, is more isolated, so as to give the appearance of a repetition rather than a continuation of the pattern. The fins are all supported by strong conical spines, or rather spurs. They correspond in number with those of *Diplacanthus*, namely, two pectoral, two ventral, two dorsal, and one anal. They are all grooved longitudinally, the ridges between the grooves being slightly crenulated, as in *Ctenacanthus*. A few transverse lines (indicating, perhaps, periods of growth) occur near the base of the spines, crossing the longitudinal pattern, and causing the reticulate character which suggested the specific designation for the Balruddery spine described by Professor Agassiz. The pectoral spines are nearly as broad as long, short, and recurved. They are so firmly attached to strong coracoids that the latter appear to be integral portions of the base of the spines. The pectoral spines are easily distinguished from the other fin spines by the arrangement of the superficial pattern. In these the ridges run parallel with the posterior margin, whereas in the dorsal and anal fins they coincide with the anterior curve of the spine. The ventral spines are small; they are situated far back, in close proximity to the anal fin. The interspace between the pectoral and ventral fins is armed with three pairs of defensive spines, similar in character to, but somewhat smaller than, the ventral spines. Properly speaking, they are elongated scutes, forming part of the dermal envelope. They have a shallow cavity where attached to the integuments, and the cast of this depression when the spine is removed much resembles a broad scale. The great development of this cutaneous armature has suggested the specific affix I have given to this fish. Some other genera of Acanthodeans show a tendency to this character; for instance, Professor Agassiz describes the occurrence of two small ventral spines, situated between the pectoral and ventral fins, in *Diplacanthus crassispinus*, and some specimens of *Acanthodes Mitchelli* have faint traces of the same peculiarity. The anterior dorsal spine is inserted over the central pair of ventral scutes, or nearly midway between the pectoral and ventral fins. It is larger than the pectoral spine, and slopes backwards at a considerable angle. The spine figured by Professor Agassiz in the " Poissons Fossiles du Vieux Grès Rouge," plate 32, fig. 25, is probably the anterior dorsal spine of his species. The great inclination of the spine suggested the generic title *Climatius*. The second dorsal spine is longer, straighter, and more slender than its companions. The anterior margin is quite straight, but the hinder limb bulges out about midway between the apex and the base. The anal spine is situated slightly in advance of the base of the second dorsal spine. It is intermediate, both in size and character, between the two dorsal spines, being longer and straighter than the one, but shorter and more bent than the other. Some specimens retain faint traces of the organs attached to these spines. There is a doubt whether they were composed of true fin rays or not. My own opinion is that they were membranous, as in the other genera of Acanthodean fishes, and that the appearance of striæ is to be attributed to the impression of the longitudinal series of minute scales with which they were invested. I have already alluded to the extraordinary development of certain scales on the ventral surface of the body. A repetition of the same character, although not to the same extent, occurs on the dorsal ridge, the interval between the occiput and the first dorsal fin being roofed by a single row of umbonated scales, not unlike those occurring in the genera *Saurorhamphus*, *Euryphol is*, and *Dercetis*, although not so large in proportion to the dimensions of the fish. The scales on the other parts of the body are very minute, and resemble those of the other Acanthodean fishes in form and arrangement. The sculpturing of the surface is shown in the enlarged figure on the plate. The course of the lateral line is seen in some of the specimens. It runs along the flank about mid-distance between the dorsal and ventral margins.

I have recently received some spines from the Farnell beds, which correspond both in size and character with the specimens figured by Agassiz from Balruddery. They leave no doubt in my mind but that they are distinct from the species I have described; I therefore retain the specific name *C. scutiger* for the small species, leaving the Agassizian name for the larger species, but removing it from the Placoid order to the Acanthodean family of the Ganoids.

Locality.—All the best specimens I have examined of this fish are from the Farnell locality, where it appears to be one of the most abundant fossils. I am informed, however, by the Rev. Hugh Mitchell that it has also been found by him at Cauterland, in the parish of St. Cyrus; and at Tealing, five miles to the north of Dundee, by Mr. Walter McNicol.

EXPLANATION OF PLATE VIII.

Fig. 1. *Climatius scutiger*, from Mr. Mitchell's original specimen.
Fig. 2. Ditto, belonging to Mr. Powrie.
Fig. 3. Ditto, ditto.
Fig. 4. Ditto, belonging to Mr. Brewster.
These four figures are twice the size of nature.
Fig. 5. *Climatius scutiger.* 1st dorsal spine.
Fig. 6. Ditto. Pectoral spine.
Fig. 7. Ditto. Anal spine.
Fig. 8. Ditto. 2nd dorsal spine.
Fig. 9. Ditto. Pectoral spines and attachments.
These five figures are four times the size of nature.
Fig. 10. *Climatius scutiger.* Scales highly magnified.
Fig. 11. *Climatius reticulatus.* 1st dorsal spine from Agassiz's "Poissons Fossiles du Vieux Grès Rouge," pl. 33, fig. 25.
Fig. 12. *Climatius reticulatus.* 2nd dorsal spine from Farnell.
Fig. 13. Ditto. Pectoral spine from Farnell.
The last three figures are the size of nature.

P. DE M. GREY EGERTON.

Oulton Park, December 1860.

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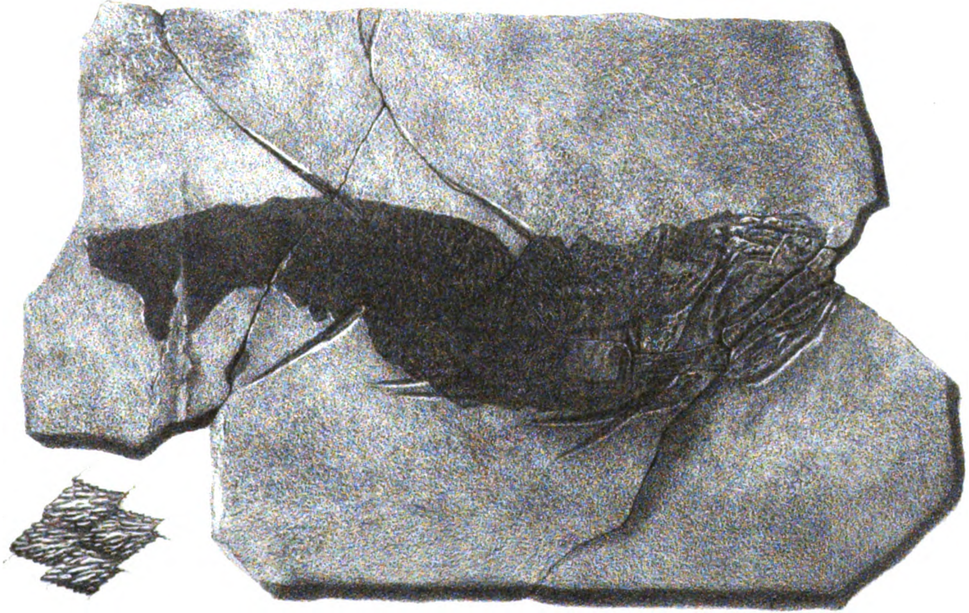

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BRITISH FOSSILS.

DECADE X. PLATE IX.

DIPLACANTHUS GRACILIS.

[Genus DIPLACANTHUS. AGASSIZ. (Sub-kingdom Vertebrata. Class Pisces. Order Goniolepidoti. Family Acanthodei.) Body fusiform. Tail heterocercal. Fins membranous, each supported by a spine. Two dorsal fins, one anal fin, two pectoral fins, and two ventral fins. Mouth large. Teeth conical.]

The genus *Diplacanthus* comprises a greater number of species than any other Acanthodean genus, at the same time it does not appear to have been nearly so numerous in individuals as the allied genus *Cheiracanthus.* Professor Agassiz has described four species, viz., *Diplacanthus striatus* from Cromartie, *Diplacanthus striatulus* from Lethen, *Diplacanthus longispinus* from both the above-mentioned localities, and *Diplacanthus crassispinus* from Caithness and Orkney. To these Professor M'Coy has added two species from the latter locality, viz., *Diplacanthus gibbus* and *Diplacanthus perarmatus.* The newly-discovered ichthyolitic deposit of Farnell has supplied a seventh species, which I proceed to describe.

Description.—The only specimen I have yet seen of this species belongs to the Rev. Henry Brewster of Farnell, and was forwarded to me with many other interesting specimens by Mr. Powrie of Reswallie, Forfar. It is in excellent preservation with the exception of the extremity of the tail, which is wanting. It measures four inches in length by three-quarters of an inch in depth. Were the specimen entire, it would probably be half an inch longer. On comparing these dimensions with those of the other species, it appears that the proportion of the depth to the length is considerably less in the species under consideration. *Diplacanthus striatulus* is in this respect most like *Diplacanthus* *gracilis*, but the difference of the depth to the length in an individual of similar length, namely four inches, would be a quarter of an inch in excess. In consequence of this striking feature the Farnell *Diplacanthus* is at once recognized by its slender form and elegant proportions. The head is small, but remarkable for the large size of the oral aperture. The dentigerous bones, from the posterior angle of the mouth to the snout, measure three quarters of an inch. They seem to have been armed with a single row of conical teeth, the impressions of which are discernible, although rather indistinct. In this character the genus *Diplacanthus* resembles *Cheiracanthus* and *Cheirolepis*, and departs from *Acanthodes*. The orbit is placed well forward, and rather high in the skull. The arrangement of the opercular bones and branchiostegous rays corresponds with that of the homologous parts in the genus *Cheiracanthus*. The pectoral spine on either side is attached to a strong coracoid bone, having a straight styliform shaft, and an expanded base. The spines themselves are long, straight, and slender. The ventral spines are about half the length of the pectoral spines, and slender in proportion. They are situated nearer to the anal fin than to the thoracic arch. The position of the first dorsal spine is the most distinctive feature of the species. In all the other Diplacanths it is inserted immediately behind the supraoccipital process, nearly above the base of the pectoral fins, and is the strongest spine of the series, whereas in this species it is situated midway between the occiput and the second dorsal spine, over the interspace between the pectoral and ventral fins. It is also smaller than the second dorsal and anal spines. These characters may hereafter prove of generic value. The second dorsal spine occupies its normal place immediately opposite the anal spine. It is quite straight and much longer than the first dorsal spine. The anal spine resembles it in all respects except in size, in which it is rather inferior. All these spines are straighter and slighter than the fin defences of the allied species. The base of the caudal fin is large, the lower lobe rounded posteriorly, and the fin broad. The upper lobe is deficient; some traces remain of the endoskeleton in the preservation of the superior spinous processes of the anterior portion of the vertebral column, which seem to have been partially if not wholly ossified. The scales are minute, having a rhomboidal outline and a granular surface.

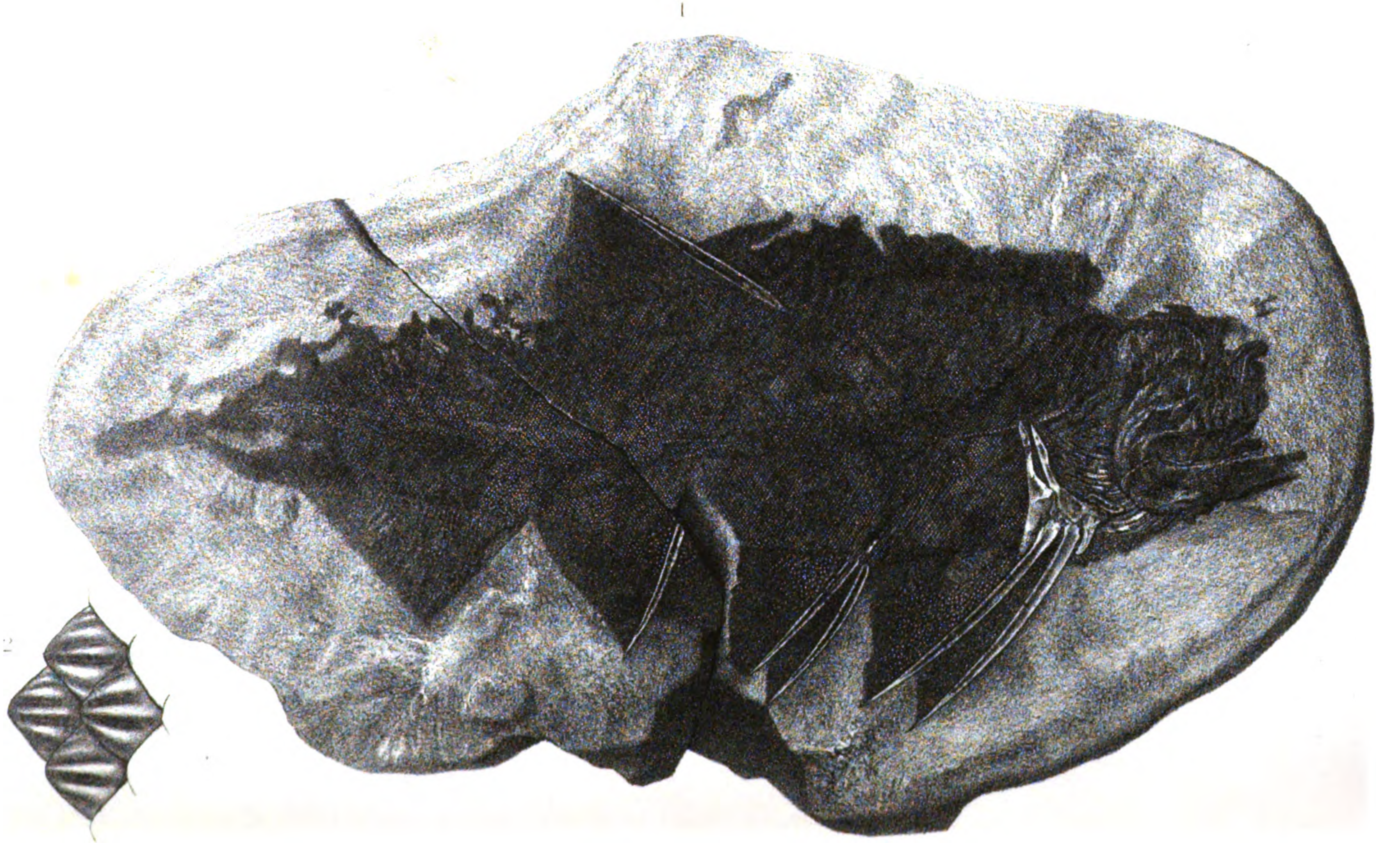
Locality.—The specimen figured was found in the Farnell beds, associated with *Acanthodes Mitchelli, Climatius reticulatus* and *scutiger*, *Parexus recurvus*, and other fossils characteristic of the Old Red Sandstone of that locality.

EXPLANATION OF PLATE IX.

Fig. 1. *Diplacanthus gracilis*, belonging to Mr. Brewster.
Fig. 2. Scales highly magnified.

P. DE M. GREY EGERTON.

Oulton Park, January 1861.



CHEIRACANTHUS LATUS *Egerton*

BRITISH FOSSILS.

DECADE X. PLATE X.

CHEIRACANTHUS LATUS.

[Genus CHEIRACANTHUS. AGASSIZ. (Sub-kingdom Vertebrata. Class Pisces. Order Goniolepidoti. Family Acanthodei.) Body fusiform. Tail heterocercal. Fins membranous, each supported by a strong spine. One dorsal fin, one anal fin, two pectoral fins, and two ventral fins. The dorsal spine situated above the interspace between the ventral and anal fins. Pectoral spines articulated to two strong coracoid bones. Scales minute. Teeth small, conical.]

The generic characters of *Cheiracanthus* are so clearly defined by Professor Agassiz in the "Poissons Fossiles du Vieux Grès Rouge," and the differences between this and the other Acanthodean genera so fully elucidated, that neither amendments nor additions are required notwithstanding the rapid progress of discovery since the publication of this standard work. Three species are therein described, *Cheiracanthus Murchisoni* from Gamrie, *Cheiracanthus microlepidotus* from Lethen and Cromartie, and *Cheiracanthus minor* from Orkney. Professor M'Coy has since described two species, *Cheiracanthus pulverulentus* and *Cheiracanthus grandispinus*, both from Orkney, the latter being the largest and most striking species of the genus. In consequence of the stimulus given to the exploration of the Old Red Sandstone deposits of Scotland by the meeting of the British Association at Aberdeen in September 1859, localities which had been previously but slightly examined were opened up, and yielded a rich harvest to the scientific labourers in Palæontology. Amongst others, the quarries at Tynet Burn were extensively explored through the liberality of the late Duke of Richmond, who employed a gang of workmen expressly for the purpose. Some of the best specimens discovered were forwarded to me by his Grace for examination, and amongst other novelties and many well-known species, I detected a new species of *Cheiracanthus*, which I have named *Cheiracanthus latus*.

Description.—On separating all the specimens of *Cheiracanthus* from the other genera with which they were associated it was evident that they indicated two distinct forms, one with a long tapering body and the fins rather distant from each other, the other short and thick, and having the fins closely approximated. The former is probably identical with *Cheiracanthus microlepidotus*, so common at Lethen; the latter I consider to be new. Both species appear to have been very abundant in the Tynet locality and to have been gregarious, but *Cheiracanthus latus* seems to have been most numerous. The collection forwarded to me contained above fifty examples, more or less perfect, of this fish. The length of an average-sized specimen is about six inches from the nose to the extremity of the tail, and the depth in front of the ventral fins one inch and a half, being an excess of one quarter of an inch as compared with a specimen of *Cheiracanthus microlepidotus* of similar length. The head is seen in profile, and measures an inch and a quarter in length from the point of the lower jaw to the posterior edge of the operculum. The mouth is large and horizontal; the teeth are not preserved in any of the specimens. Judging from the character of the dentigerous bones they were probably small and in single rows. The branchiostegous rays are very numerous, and extend high up in the opercular space. They are composed of a harder substance than the surrounding parts, being almost as dense as the fin spines, and are consequently preserved in most of the specimens. The pectoral fins are large and triangular. They are supported by a pair of strong spines, slightly curved and measuring one inch and a quarter in length. These are attached to a pair of coracoid bones, broad at the point of articulation and tapering upwards. A short process extends downwards from the same point on either side, meeting its fellow in the median line, and completing the thoracic arch. The large expanse of the pectoral fins required a powerful fulcrum such as this to enable them to fulfil their functions. The ventral fins are situated midway between the pectoral and anal fins. The spines supporting them are straight, and have their bases inserted in the integuments without any trace of pelvic bones. The dorsal fin occupies the middle of the back, the point of insertion of the dorsal spine being opposite the interspace between the ventral and anal fins. It is a large triangular fin attached to a long and straight spine deeply implanted in the muscular tissue. The anal fin spine occurs midway between the ventral spines and the base of the caudal fin, the membranous portion extending as far as the anterior margin of the latter organ.

The pedicle of the tail is very deep, and terminates in a broad fin, of which the upper lobe greatly exceeds the lower lobe in extent. The scales are smooth, umbonated below, and neatly sculptured on the outer surface with four or five parallel grooves. They are of uniform size over the entire body. The broad tail, large fins, and close arrangement of these on the ventral surface distinguish this species from all those hitherto described.

Locality.—All the specimens I have seen of this species are from Tynet Burn, where they occur in nodules similar to those found in the contemporaneous deposit at Lethen Bar.

EXPLANATION OF PLATE X.

Fig. 1. *Cheiracanthus latus.* Size of nature.
Fig. 2. Scales magnified.

P. DE M. GREY EGERTON.

Oulton Park, November 1860.

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54 SE. Part of Warwickshire.
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55 SW. Part of Hereford.
55 SE. Part of Hereford and Worcester.
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61 NE. Part of Shropshire and Staffordshire.
61 SW. Part of Shropshire.
61 SE. Part of Shropshire.
*62 NE. Lichfield, part of Staffordshire.
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*62 SW. Part of Staffordshire, including the Coalfield.
*62 NW. Part of Staffordshire, including the Coalfield.
*63 NW. Ashby-de-la-Zouch, part of Leicestershire.
63 NE. Leicester.
*63 SW. Hinckley, part of Leicestershire and Warwickshire.
*63 SE. Part of Leicester, Warwick, and Northamptonshire.
71 NE. Nottingham.
71 NW. Nottingham, part of Derbyshire.
*71 SW. Derby.
71 SE. Part of Nottinghamshire.
72 NW. Hanley. Part of Staffordshire.
72 NE. Part of North Staffordshire and of SW. Derbyshire.
72 SW. Central Part of Staffordshire.
*72 SE. Part of Staffordshire and SW. Derbyshire.
*73 NW. Part of Cheshire.
73 SW. Part of Shropshire.
73 SE. Part of Shropshire and Staffordshire.
73 NE. Crewe.
74 NW. Part of Denbigh, Merioneth, and Caernarvon.
74 NE. Part of Denbigh, Flint, Shropshire, and Merioneth.
74 SW. Part of Montgomery, Denbigh, and Merioneth.
74 SE. Part of Shropshire, Montgomery, and Denbigh.
75 NW. Part of Caernarvon.
75 NE. Part of Caernarvon, Merioneth, and Denbigh.
75 SW. Part of Caernarvon.
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76 N. Part of Caernarvon.
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77 N. Part of Holyhead Island.
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